SOQUEL CREEK WATERSHED ASSESSMENT AND ENHANCEMENT PROJECT PLAN

SANTA CRUZ COUNTY RESOURCE CONSERVATION DISTRICT
820 BAY AVENUE, SUITE 128
CAPITOLA, CALIFORNIA 95010
(831) 464-2950

Prepared for the Santa Cruz County Resource Conservation District
Based on information provided by D.W. ALLEY and Associates; Balance Hydrologics, Inc; Greening Associates and the Coastal Watershed Council.
Compiled and edited by Strelow and Associates
Revised on November 20, 2003

NOVEMBER, 2003

SOQUEL CREEK WATERSHED ASSESSMENT AND ENHANCEMENT PROJECT PLAN

Prepared for the Santa Cruz County Resource Conservation District
Based on information provided by D.W. ALLEY and Associates; Balance Hydrologics, Inc;
Greening Associates and the Coastal Watershed Council.
Compiled and edited by Strelow and Associates
Revised on November 20, 2003

SANTA CRUZ COUNTY RESOURCE CONSERVATION DISTRICT
820 BAY AVENUE, SUITE 128
CAPITOLA, CALIFORNIA 95010
(831) 464-2950

FUNDED BY:

THE COASTAL CONSERVANCY
CALIFORNIA DEPARTMENT OF FISH AND GAME

November, 2003

This project was funded in part by the Salmon and Steelhead Trout Restoration Account (SB 217, 1997-Thompson) as administered by the California Department of Fish and Game.

This plan and appendices should be cited as:
Santa Cruz County Resource Conservation District. November 2003. The Soquel Creek Watershed Assessment and Enhancement Project Plan

D.W. ALLEY and Associates. March 2003. "Soquel Creek Salmonid Assessment and Enhancement Plan, 2003" *in* Santa Cruz County Resource Conservation District. November 2003. Soquel Creek Watershed Assessment and Enhancement Project Plan.

Balance Hydrologics, Inc. March 2003. "Soquel Creek Watershed Assessment: Geomorphology and Baseflow Hydrology" *in* Santa Cruz County Resource Conservation District. November 2003. Soquel Creek Watershed Assessment and Enhancement Project Plan.

Greening Associates. March 2003. "Soquel Creek Riparian Vegetation Assessment." Santa Cruz County Resource Conservation District. November 2003. Soquel Creek Watershed Assessment and Enhancement Project Plan.

ACKNOWLEDGEMENTS

TECHNICAL ADVISORY COMMITTEE (TAC) MEMBERS

Bill Arkfeld, Water Resource Control Engineer, Regional Water Quality Control Board, **Donna Bradford**, Resource Planner, Santa Cruz County Planning Department, **Richard Casale,** District Conservationist, CPESC 3, USDA Natural Resources Conservation Service, **Karen Christensen**, Executive Director, Santa Cruz County Resource Conservation District, **Mike Cloud**, Hydrologist, Environmental Health Services Department, Santa Cruz County, **Sara Duckler**, Hydrologist/Geomorphologist, **Marty Gingras**, Fisheries Biologist, California Department of Fish and Game, **Kate Goodnight**, Project Manager, California Coastal Conservancy, **Bobbie Haver**, Watershed Coordinator, Santa Cruz County RCD, **Karen Holl**, Ecology Professor, University of California Santa Cruz, **Brook Kraeger**, Hydrologist, **Kallie Marie Kull**, Fish Net-4-C, **Neil Lassettre**, Hydrologist, **Jennifer Nelson**, Fisheries Biologist, California Department of Fish and Game, **John Ricker**, A Land Use and Water Quality Program Coordinator, Santa Cruz County Environmental Health Services Department and Santa Cruz County RCD Board Member, **Kristen Schroeder**, Fisheries Biologist, Santa Cruz County Planning Department, **Vasiliki Vassil**, Geologist and Santa Cruz County RCD Associate Board Member.

PUBLIC ADVISORY GROUP (PAG)

In order to get input from the public and interested stakeholders, the PAG was formed and key volunteers including landowners, Friends of Soquel Creek, Save the Habitat, Soquel Creek Water District, the City of Capitola, residents and others participated and reviewed the draft hydrology, fisheries and vegetation assessments. In addition, the PAG contributed to the development of the outreach and education recommendations. Public meetings occurred where information about the assessments and Plan were disseminated and opportunities for public comment were provided.

PUBLIC OUTREACH EFFORTS

The Santa Cruz County Resource Conservation District conducted outreach to interested parties, landowners and community members throughout the development of the Soquel Creek Assessment and Enhancement Plan. Over 3000 residents were notified of the process and invited to participate. There were two workshops, an upper watershed landowner meeting, and four Public Advisory Group (PAG) meetings. More than ninety individuals attended. Press releases; direct mailing and individual landowner contacts were the primary outreach mechanisms utilized during the development of the Soquel Creek Assessment and Enhancement Plan.

RCD PROJECT CONTRIBUTORS

Don Alley, **D.W. Alley and Associates**, Shawn Chartrand & Barry Hecht, **Balance Hydrologics Inc.**, Tamara Doan, **Coastal Watershed Council**, Kate Goodnight, **California Coastal Conservancy**, Marty Gingras, **California Department of Fish and Game**, John Ricker, **Santa Cruz County, RCD Board of Directors**, Suzanne Schettler, **Greening Associates**, Kristen Schroeder, **Santa Cruz County Planning Department**, Stephanie Strelow, **Strelow Consulting**, Karen Christensen, Bobbie Haver, Carey Cooper, Annette Pennock, **Santa Cruz County Resource Conservation District**.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

STATEMENT OF PROBLEM / ISSUES

In the Soquel Creek watershed, steelhead (*Oncorhynchus* mykiss) populations have declined in recent years while coho salmon (*Oncorhynchus* kisutch) have been extirpated. The causes to steelhead decline and coho extirpation are due to numerous mechanisms including declines in the quality and quantity of instream habitat, localized increases in water temperature -- in part due to historic losses of riparian vegetation, increased sediment loading from historic land uses and more recent episodic events and the occurrence of low baseflow sometimes resulting in no flow conditions in lower parts of the mainstem.

PURPOSE OF ASSESSMENT

The mission of the Santa Cruz County Resource Conservation District (RCD) is to help citizens protect, conserve and restore natural resources through information, education, and technical assistance programs. Consistent with that mission, the purpose of the Assessment is to propose and justify a prioritized list of projects and actions for implementation by cooperating residents and land managers that will improve conditions for coho salmon and steelhead.

MAJOR FINDINGS AND SUMMARY OF LIMITING FACTORS

Over the past 50 years, baseflows during “dry years” in Soquel Creek have decreased by 2-4 cfs at the USGS gage. Overall lateral channel stability of Soquel Creek was relatively stable during the past 54 years with minor adjustment at several points of meander along the East Branch and mainstem. Vertical channel adjustment has been spatially variable over the past 54 years with some reaches having aggraded while other reaches having degraded. Major sediment production from natural sources occurs in both the East and West Branches and is most pronounced following an earthquake, large magnitude flood or forest fire and is usually related to landsliding. Chronic sources of sedimentation are problematic.

Overall, riparian vegetation is in moderately healthy condition. Deciduous tree density decreases slightly moving upstream while evergreen density tends to increase. Alders and cottonwoods abound in the mainstem. The major tree species are represented by a full array of size classes. Small trees are numerous and recruitment is active. The tallest deciduous riparian trees, the sycamores and cottonwoods, are generally established after heavy flow events on terraces well above the bed of the creek. Canopy cover tends to increase upstream, with the most cover occurring in the West Branch and the tributaries. Approximately 21% of sites surveyed achieved the 85% canopy closure recommended by California Department of Fish and Game (CDFG) for coho.

Several factors appear to limit distribution and abundance of steelhead. These factors include passage impediments, poor spawning habitat quality (high proportion of fine sediment, number of constricting, steep riffles below spawning glides), low spring and summer baseflows, limited amount of escape cover (provided by instream wood, undercut banks, unembedded boulders, water depth itself), elevated water temperature, and limited water depth. Throughout the watershed, low baseflows and sedimentation limit the amount and quality of rearing habitat. The same factors that limit steelhead also

limit coho salmon, although coho salmon are more sensitive to warmer water temperature.

ENHANCEMENT GOALS

1. To reduce or remove limiting factors affecting juvenile steelhead.
2. To restore coho salmon habitat where feasible.
3. To establish and protect refugia where habitat conditions are particularly suitable for steelhead and/or coho.
4. To provide outreach and educational materials to agencies and landowners regarding best management practices to protect and enhance anadromous salmonid habitat.
5. To promote implementation of projects through technical assistance, education, and financial assistance from available funding sources.
6. To develop and implement projects that will promote the following objectives:
    a. Maximize baseflow and prevent stream reaches from drying out.
    b. Maintain water temperatures throughout the watershed at levels suitable for steelhead
    c. For reaches to be managed for coho habitat, maintain temperatures at cooler levels suitable for coho.
    d. Restore and maintain riparian vegetation for proper floodplain/riparian function and stream cooling.
    e. Minimize fine sediment in spawning gravels and in rearing areas.
    f. Restore and maintain adequate levels of large woody material in the channel to provide habitat complexity.
    g. Reduce impediments to adult fish migration, particularly those caused by culverts, dams, and other structures.

SUMMARY OF RECOMMENDATIONS

The overarching goal of the Soquel Creek Watershed Assessment and Enhancement Project Plan (Assessment) is to develop and prioritize recommendations for projects and actions that will directly enhance the quantity and quality of habitat for coho salmon and steelhead. The Recommended Project List includes those specific projects and other actions/programs. The recommendations include removal of passage impediments, conservation and preservation of baseflow, erosion and sediment control measures and projects, revegetation, large wood retention, removal of non-native, invasive species, public outreach and education, monitoring activities, and acquisition of conservation easements and title. Conservation easements and land acquisition in appropriate situations can help protect habitat for coho salmon and steelhead by (1) facilitating preservation of pertinent functional values of riparian forest, (2) potentially reducing stream diversions which otherwise may reduce stream flow and habitat, and (3) potentially reducing sedimentation and runoff by reducing road construction, or reconstruction in erosion-prone areas.

Although a number of potential habitat improvement projects are prioritized, the level of detail necessary to fund and implement these projects requires further analysis. There is limited funding available through local, state, and federal grants and agencies, and the funding entities have a limited amount of time to review all prospective projects and make decisions about the feasibility, cost and overall benefit to coho salmon and steelhead habitat enhancement. It is thus important to take the first steps in defining the important elements of the higher-priority projects. These steps include a description of the project need, initial site assessment, concept-level solutions, preliminary cost estimates, and expected benefit of the project. Additionally, some projects may not necessarily be constructed solutions but could be part of a programmatic effort that will provide long-term benefit to

coho salmon and steelhead populations. In these cases, it will be important to define the initial steps that are necessary to move those programs forward.

Implementation of recommendations contained in this Assessment will involve cooperative and voluntary participation of property owners and other agencies and organizations. Strategies for education and public outreach are included in the Plan.

The Assessment also includes recommendations for a monitoring program. The primary objective of a monitoring program is to assess physical and biological changes in watershed conditions over time following implementation of enhancement actions. It is meant to monitor the success or failure of enhancement actions and provide the necessary data to adjust, or adaptively manage, the implemented enhancement program. A monitoring program will be developed with specific monitoring recommendations for the Soquel Creek Watershed to include: 1) continuing to monitor water temperature on an annual basis; 2) installing additional automated streamflow monitoring stations for the low flow months of May through September to better understand the gain and loss of streamflow; and 3) continuing to annually monitor juvenile steelhead populations to better understand how the population is influenced by baseflow, winter storm flow patterns and rearing habitat quality.

INTRODUCTION

PROJECT LOCATION

The Soquel Creek Watershed is located in Santa Cruz County between the cities of Santa Cruz and Watsonville along the Central Coast of California (see Figure 1). It is located near the southern end of the Santa Cruz Mountains. It is the second largest watershed (San Lorenzo is the largest) and is completely within Santa Cruz County with a drainage area of approximately 42 square miles. Soquel Creek empties into the Monterey Bay, a designated National Marine Sanctuary, after flowing nearly 24 miles from its headwaters at the crest of the Santa Cruz Mountains at the Santa Clara County border. The creek reaches under study include a 7-mile long West Branch, 16 miles of the East Branch, and 7.7 miles along the Mainstem.

STATEMENT OF PROBLEM / ISSUES

California salmonid populations have declined substantially during the last 50 years. As a result, the National Marine Fisheries Service listed many salmonid species throughout California as "threatened" or "endangered" under the federal Endangered Species Act. Coho salmon (*Oncorhynchus kisutch*) and steelhead (*Oncorhynchus mykiss*) in Central Coast streams were federally listed as "threatened" in the mid 1990s. Additionally, coho salmon south of San Francisco were listed by the state of California as endangered in the 1990s.

Populations of steelhead in Soquel Creek have declined in recent years, and coho salmon are now absent. The causes are related to episodic and some chronic declines in the quality and quantity of the instream habitat, from increases in temperature, turbidity, sedimentation accompanied by periods of insufficient baseflow and inadequate riparian vegetation.

PURPOSE OF ASSESSMENT

The mission of the RCD is to help citizens protect, conserve and restore natural resources through information, education, and technical assistance programs. Consistent with that mission, the purpose of the Assessment is to develop a prioritized list of projects and actions for implementation by cooperating residents and land managers that will improve conditions for coho salmon and steelhead.

The process of "Assessment development" included technical scientific assessments of geomorphology, hydrology, salmonid fishery habitat, and riparian forest integrity. These assessments were rigorous as appropriate for the purpose. However, none of the recommended projects and actions - or the reported information and analyses used to identify or justify them - should be used to enforce existing regulations or code, revise existing regulations or code, or to promulgate new regulations or code without further analysis and consideration. Local, State, and Federal resource agencies are concurrently developing (or have proposed development of) various plans that will build on the preliminary findings of this Assessment and provide for implementation of policies and programs for reduction of sediment load, protection of baseflows, provision of adequate water supply, and protection and enhancement of riparian and aquatic habitat.

As of the production date for the Soquel Creek Watershed Assessment and Enhancement Project Plan, coho salmon have been extirpated from the watershed. However, through recovery planning

processes, coho may be introduced or stray from nearby streams. Throughout this document habitat suitable for coho is referred to as "coho habitat."

PROJECT METHODOLOGY AND PARTICIPANTS

This Assessment is the result of a multi-disciplinary assessment of current and historic channel and habitat conditions in the Soquel Creek watershed, Santa Cruz County, California. Development of appendices to the Assessment included assessments of hydrology, geomorphology, riparian vegetation, and fisheries habitat. Studies began in the summer 2001 and continued into the summer of 2002. The assessments reviewed existing data and included field assessments. Field data were collected during the summer and fall of 2001 and summer of 2002. The assessments also included watershed history, an evaluation of the condition and geometry of the channel prior to disturbances of the last 10-20 years, and an assessment of the problems affecting fishery habitat. Field data was also collected during the summer of 2002 by the Coastal Watershed Council.

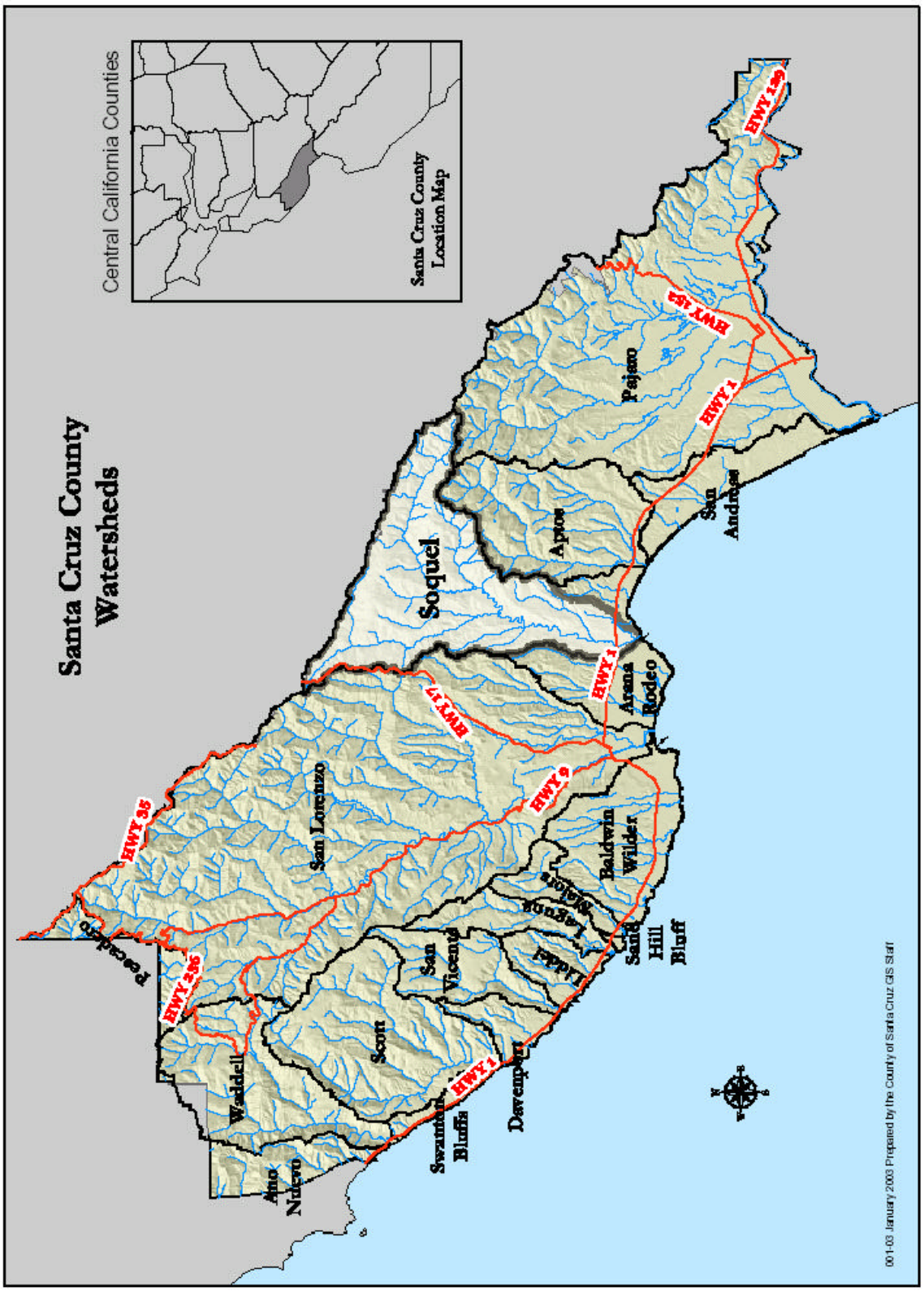
This Assessment was developed from an interpretation of the technical assessments, where the interpretation was prepared by technical and policy specialists. Narrative for the Assessment was compiled and edited by Strelow Consulting, using material provided by a number of sources including a project "technical team". The technical team members include: D.W. Alley and Associates (fisheries), Balance Hydrologics (hydrology and geomorphology), and Greening Associates (riparian vegetation). Technical material developed by team members for inclusion here are Appendices to this plan.

A Technical Advisory Committee (TAC) and Public Advisory Group (PAG) were formed to review and/or interpret the assessment findings and/or to develop recommendations. Members of the TAC were scientists and funding agency representatives. The TAC convened at feasible intervals to: review and comment on assessment methodologies; provide additional scientific expertise; and review assessment findings and recommendations. Participation of the TAC members increased coordination with concurrent projects and may facilitate permitting for recommended projects.

In order to get input from the public and interested stakeholders, the PAG was formed and key volunteers including landowners, Friends of Soquel Creek, Save the Habitat, Soquel Creek Water District, the City of Capitola, residents and others participated and reviewed the draft hydrology, fisheries and vegetation assessments. In addition, the PAG was instrumental in the development of the outreach and education recommendations. Public meetings occurred at the onset and at key points of the project, where information about the technical assessments and summary document was disseminated and opportunities for public comment were provided.

The County (or "local agencies") should work with other agencies and stakeholders to complete a watershed management plan for the Soquel Creek Watershed, which will expand on the recommendations of this Assessment and include a broad range of recommendations for implementation of policies and programs for reduction of sediment load, protection of baseflows, provision of adequate water supply, and protection and enhancement of riparian and aquatic habitat.

FIGURE 1: SOQUEL CREEK WATERSHED LOCATION



OVERVIEW

ANADROMOUS SALMONID LIFE CYCLE

Steelhead exhibit a life cycle similar to other members of the salmon family, in which they develop into adulthood in the ocean and swim to their natal stream to reproduce. Adults migrate to their home stream after 2 years (range of 1-3 years) of feeding and growth in the ocean. However, adult steelhead differ from all other salmon species in that some survive the spawning process, return to the ocean and may spawn again the next spawning season. Adult salmon of other species die after they spawn. The hatched young that emerge from the spawning gravel are known as fry and typically spend 1-2 years as juveniles in their natal, freshwater streams. Once large enough to survive ocean conditions, most make their way to the ocean in late winter and spring, undergoing physiological and coloration changes (i.e., smoltification) which allows them to osmoregulate in the saline ocean environment.

Coho salmon have an anadromous life cycle somewhat different than steelhead. Most adults return to their home streams to spawn after 18 months to 2 years in the ocean and migrate upstream earlier than steelhead, from November through February. Adults die after spawning. Juveniles spend just 1 year in freshwater before smolting. There is little intermingling of year classes, with populations forming 3 separate year classes. Consequently, if a year class of coho becomes weak due to either late flood events or drought that reduces spawning access and success, it may take several generations for that year class to recover.

An overview of habitat considerations for phases of the life cycle is provided below.

- MIGRATION. The majority of adult steelhead in small coastal streams migrates upstream from the ocean after several prolonged storms; the migration seldom begins earlier than December and may extend into May if late spring storms develop. Spawning adult fish may be impeded by bedrock falls, shallow riffles, certain logjams, culverts, bridge abutments and dams. Some impediments may completely prevent upstream migration, but most are passable at a narrow range of streamflow.

  Adult coho salmon often have more severe migrational problems than steelhead, because much of their migration period is prior to the peak flows needed to pass shallow riffles, boulder falls, and certain logjams. Access at the river mouth is also a greater problem for coho salmon, because they die at maturity and cannot wait in the ocean an extra year if access is poor due to failure of sandbar breaching during drought or delayed storm flow.

  Smolts in local coastal streams tend to migrate downstream to the lagoon and ocean primarily from March through May, although some continue to out-migrate in June. Downstream migration is occasionally blocked or restricted by an interaction of low flows and streambed percolation, and often blocked by formation of sand bar at the ocean. However, downstream migration in most Santa Cruz Mountain streams is only a substantial problem during extreme drought.

- SPAWNING. Steelhead and coho salmon require spawning sites with small to medium-sized gravels (from 1/4" to 3 1/2" diameter) having a minimum of fine material (sand and silt) mixed with them and with adequate flows of clean water moving over and through them. Females usually excavate their nests in the center of the channel thalweg (deepest point) in glides at

the tails of pools (or the heads of riffles above the break), where water infusion of the substrate is maximized, and streambed scour is minimized. They may be forced to spawn in deeper riffles and runs if stream depth is too shallow at pool tails. Increased fine materials from sedimentation, or cementing of the gravels with fine material, restrict water and oxygen flow through the redd (nest) to the fertilized eggs. This reduces hatching success.

Steelhead and coho spawning success is limited by scour from some winter storms. The production of young-of-the-year fish is related to spawning success, which is a function of the quality of spawning conditions and ease of spawning access to the upper reaches of tributaries, where spawning conditions are generally better.

- REARING HABITAT**.** Juvenile steelhead are generally identified as young-of-the-year (young-of-the-year; first year) and yearlings (second year). Except in streams with high mean summer flow volumes (greater than 0.2 to 0.4 cfs per foot of stream width), steelhead usually require two summers of stream residence before reaching smolt size. However, in the mainstem of Soquel Creek a portion of the young-of-the-year age class grows sufficiently to require only one year of stream residence. Rearing habitat and food availability can be greatly reduced by presence of sediment filling pools and embedding gravel and rocks in riffle areas.

- OVERWINTERING HABITAT. Deeper pools, undercut banks, side channels, logs, upturned tree roots, debris accumulations and especially large, unembedded rocks provide shelter for fish against the high flows of winter. In some years, such as 1982, extreme floods may make overwintering habitat the critical factor in steelhead production. In most years, however, if the pools have sufficient larger boulders or undercut banks to provide summer rearing habitat for yearling steelhead, then these elements are sufficient to protect overwintering steelhead against winter flows. For coho salmon fry that may emerge in late winter and spring, overwintering habitat is critically important to their survival.

- WATER TEMPERATURE. Existing data indicates that temperatures below 20ºC (68ºF) are best suited for the success and production of steelhead-rainbow trout. Regarding maximum water temperature tolerance in steelhead, steelhead lethal temperatures are in the range of 24-29ºC (75.2º- 84.2ºF). Water temperatures as high as 24ºC were measured in lower Soquel Creek in August of 1998.

  Juvenile coho salmon can potentially tolerate temperatures nearly as high as steelhead, but usually are found at much cooler temperatures. Existing data suggest that juvenile coho salmon prefer temperatures of 12-14ºC (53.6-57.2ºF), do not persist in streams where summer temperatures reach 22-25ºC (71.6-77ºF), and temperatures exceeding 25-26ºC (77-78.8ºF) are “invariably lethal.”

GENERAL WATERSHED MORPHOLOGY

Soquel Creek is a coastal stream located in the central part of Santa Cruz County, on the central California coast between the cities of Santa Cruz and Watsonville. Soquel Creek empties into the Monterey Bay National Marine Sanctuary after flowing nearly 24 miles from its headwaters at the crest of the Santa Cruz Mountains at the Santa Clara County border. Before flowing into Monterey Bay, Soquel Creek forms a seasonal lagoon and estuary that provides important habitat for fish and wildlife.

The Soquel Creek Watershed includes approximately 26,880 acres or 42 square miles of land. Elevations vary from sea level at the estuary to 3,000 feet at the headwaters. The basin is triangular in shape, 12 miles wide at the base along the crest of the Santa Cruz Mountains and less that one mile wide at the apex in Capitola. The total length of fish-bearing streams in the watershed is approximately 50 miles.

The upper watershed has two major tributary basins, the East Branch and the West Branch, while the lower watershed has one major tributary basin, Bates Creek. The respective drainage areas of these tributary basins are: 18, 13 and 5 square miles. Significant smaller tributaries in the East Branch include Amaya Creek and Hinckley Creek and in the West Branch include Hester Creek. The eastern watershed is drained by Fern Gulch, Ashbury Gulch, Amaya Creek, Hinckley Creek and the East Branch of Soquel Creek. The West Branch of Soquel Creek originates at the confluences of Burns and Laurel creeks and drains 11.3 square miles of the western watershed, with Hester Creek as a major tributary.

Two primary tributaries feed directly into the mainstem of Soquel Creek, which is formed by the confluence of the East Branch and the West Branch. One is the Love Creek/ Moores Gulch sub-basin, which joins the mainstem from the west at approximately 6 miles from the ocean near Casalegno's Store on Old Soquel-San Jose Road. The other is the Bates Creek/ Grover Gulch sub-basin, which joins the mainstem from the west near the Bargetto Winery, approximately 0.8 miles upstream of Soquel Avenue Bridge and 2.2 miles from the ocean.

CLIMATE

The Soquel Creek Watershed has a Mediterranean climate with cool wet winters and dry warm summers. Approximately 80% of total annual rainfall occurs from November to April, and over 50% occurs between December and February. Mean annual precipitation varies from 23 inches in Capitola to 27 inches in Soquel to over 40 inches in the upper watershed. In recent decades there has been a tendency for peak precipitation to occur later in the rainy season, and any such shifts will significantly limit the production of coho salmon by delaying upstream migration and by increasing the risk of redd scour.

Smith (1990; et seq.), the Monterey Bay Salmon and Trout Project, and Nelson (1993; 1994) suggest that the timing of the peak spawning migration in Scott and Waddell creeks has shifted about two weeks later in the season since the 1930s. Bryant (1994) in the National Marine Fisheries Service status review concluded that "Spawning migrations in most California coastal streams and rivers have shifted to later in the spawning season, possibly due to degraded conditions within the watersheds, rivers, and estuaries." This shift in run-timing may also be explained by a well-documented shift in timing of precipitation.

Because rain and runoff are extremely rare in the Soquel Creek watershed during summer and fall months and watershed areas are relatively small, natural levels of stream flow during summer and fall

are very low and are particularly limiting for the survival of coho salmon and steelhead.

GEOMORPHOLOGY AND HYDROLOGY

Geology

Topography of the downstream portions of the watershed is gently sloping, and becomes moderately to steeply sloping upstream. Watershed relief is dramatic, with elevations in the headwaters reaching over 3000 feet only 10 miles from the mouth. The upper reaches of the watershed are characterized by steep slopes and narrow canyons that include the San Andreas Fault Rift Zone. Large, natural, deep-seated landslides are common. Deeply weathered bedrock, steep slopes, and earthquake activity with heavy, prolonged rainfall promote large-scale landslides. These large slope failures generally originate at ridge tops, terminate along stream banks and can cover millions of square feet.

Coho salmon and steelhead habitat is highly susceptible to sedimentation from natural and human-induced erosion and mass wasting, because local geology is dominated by poorly consolidated sandstone and shale that are intrinsically mechanically weak and have been further weakened by pervasive fault-related fracturing and shearing. Base flow levels, and stream flow response to groundwater extraction, is predictably and substantially affected by structurally-controlled drainage and fault-related juxtaposition of different rock types with vastly different permeabilities.

Hydrology

The largest flood on record occurred on December 22, 1955, with an estimated peak discharge of 15,800 cfs. Two additional significant storm events occurred in January 1982 and January 1995 with peak discharges of 9,700 cfs (25-year storm) and 8,800 cfs (20-year storm), respectively.

U.S. Geological Survey (USGS) flood frequency estimates for Soquel Creek are as follows:

- 100-year event: 13,058 cubic feet per second (cfs);
- 50-year event: 11,548 cfs;
- 10-year event: 7,385 cfs; and
- 2-year event: 2,429 cfs.

Most flows necessary for migration of adult coho salmon and steelhead occur from December to April. These flows breach the sandbar that is common at the mouth of Soquel Creek. Late onset of such flows will delay or abbreviate the spawning migration of adult coho salmon and steelhead. No large municipal reservoirs and few private reservoirs have been constructed in the area, thus the flows necessary for migration and spawning are generally unimpaired by development.

Reduced flow (and depth) due to water diversion impedes migration of adult and juvenile coho salmon and steelhead between storms during relatively dry winters, and the range of rearing juveniles is severely limited by water depth and water velocity during summer months and periods of drought. Reduction of surface flow by pumping of shallow and deeper groundwater is also problematic, because the cumulative effects are relatively difficult to identify and measure.

Seasonal low flows usually decline from May to the first rains in October or November. Base flow necessary for coho salmon and steelhead rearing during this period is severely limited due to interactions between the relatively small size of the watershed, climate, geology, and land use, such as water diversions and groundwater extraction. Few local studies have quantitatively characterized instream flow needs for fisheries. However, an Instream Flow Incremental Methodology study of lower Scott Creek, Santa Cruz County (Snider et al. 1995) illustrates habitat-flow limitations typical of streams in the Big Basin Hydrologic Unit. Snider found that optimal weighted useable area for juvenile coho salmon and steelhead in Scott Creek are provided at 20 cfs (.57m^3/s). Juvenile habitat availability declines very rapidly as flows fall below 8 cfs (.23 m^3/s), and only half of the maximum habitat remains at 5 to 6 cfs (.14-.17 m^3/s); however, median flows in Scott Creek in August, September and October are 2 cfs (.06 m^3/s) or less (roughly 16% of maximum habitat availability).

Water rights in the watershed have been adjudicated, but the adjudication did not call for appointment of a water master and it is not clear to what degree provisions of the adjudication are being implemented. Unregistered riparian diversions and wells affecting groundwater from the creek are likely prevalent. Groundwater extraction limits streamflow by either directly drawing on streamflow by capturing underflow from the alluvial sediments, or by long-term regional lowering of the water table and reduction of groundwater discharge to the stream.

BIOLOGICAL RESOURCES

Major portions of the Soquel Creek Watershed are wooded, including large, extensive stands of coastal redwoods, tan oak, madrone and Douglas-fir. Natural forest is not widespread in the lower elevations, but mixed evergreen and coniferous forests dominate the upper watershed. Riparian trees such as sycamore, alder, cottonwood and willow are found along the lower stream bank within broad flood plains.

The watershed provides diverse habitat for a variety of plants and animals including special status species. The Soquel Creek Watershed has historically supported coho salmon, although coho are believed extirpated since 1992. Steelheads are still present in the watershed according to annual stream surveys. Each summer a sandbar is constructed at the mouth of the creek to create and manage a lagoon within the City of Capitola. The lagoon often provides good habitat for juvenile steelhead, and has been estimated to support as many as 3,000 juvenile steelhead.

In addition to coho and steelhead, other special-status species have been reported for areas within the Soquel Creek watershed and are summarized in Table 1. The two special-status plant species that are known to occur within the Soquel Creek watershed are flowering annuals that occur in open and sunny habitats of Valley and Foothill Grassland and Coastal Prairie rather than in the relatively shaded understory of riparian forest.

TABLE 1: SPECIAL-STATUS SPECIES WITHIN THE SOQUEL CREEK WATERSHED		
SPECIES	**STATUS**	**COMMENTS**
PLANTS		
Holocarpha macradenia Santa Cruz Tarplant	Federal Threatened State Endangered CNPS List 1B	Occurs in Coastal Prairie, Valley and Foothill Grassland, not in riparian vegetation
Plagiobothrys diffusus San Francisco Popcorn-Flower	State Endangered CNPS List 1B	Occurs in Coastal Prairie, Valley and Foothill Grassland, not in riparian vegetation
WILDLIFE		
Oncorhynchus mykiss Steelhead	Federal Threatened CDFG Species of Special Concern	A principal focus of the fisheries assessment
Oncorhynchus kisutch Coho Salmon	Federal Threatened State Endangered	A principal focus of the fisheries assessment. Probably extirpated. Last adult captured in 1992.
Rana aurora draytonii California red-legged frog	Federal Threatened CDFG Species of Special Concern	Detected in Upper East Branch in Soquel Demonstration State Forest, upstream of Ashbury Gulch.
Eucyclogobius newberryi Tidewater Goby	Federal Endangered CDFG Species of Special Concern	Reported to occur from Highway 1 to Capitola Beach
Clemmys marmorata pallida Southwestern Pond Turtle	CDFG Species of Special Concern	Occurs east of Conference Grounds and downstream, also in vicinity of quarry, Millpond and Soquel Demonstration State Forest
Rana boylii Foothill Yellow-legged Frog	CDFG Species of Special Concern	Observed during assessment at numerous locations in Soquel Creek
Tryonia imitator California Brackishwater Snail		Extirpated; occurs at coastal lagoons including, formerly, “Soquel Marsh”
Danaus plexippus Monarch Butterfly		Winters near Rispin Mansion along the lagoon

LAND USE

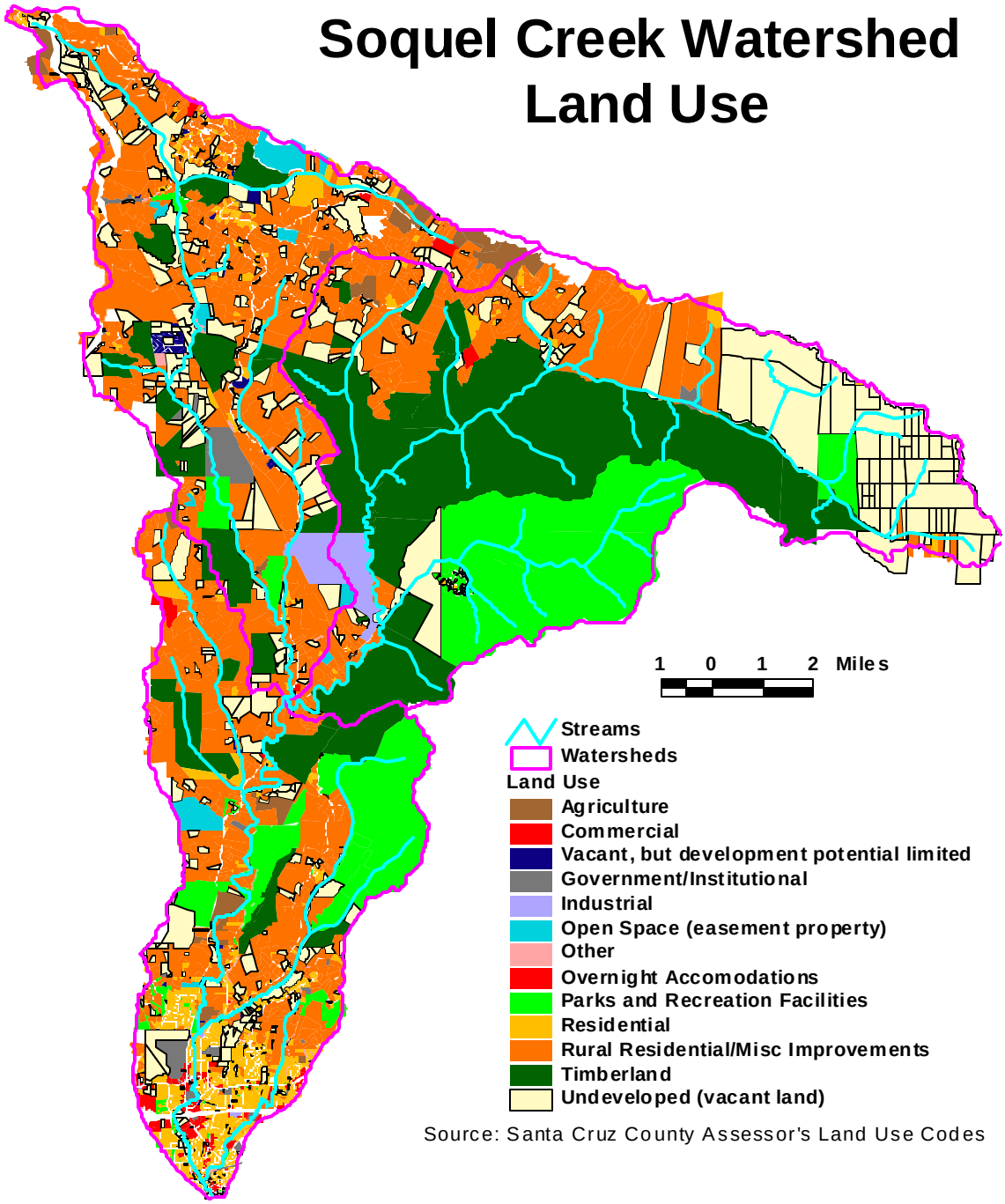
Land Use Types

Lands within the Soquel Creek Watershed are situated mostly in the unincorporated portion of Santa Cruz County. The lower portion of the creek is within the City of Capitola. Land uses within the watershed include urban development, rural residential development, agriculture, equestrian use, parks and recreation, mining and timber harvesting.

The lower reaches of Soquel Creek flow through a residential and mixed-use urban area (the unincorporated community of Soquel and the City of Capitola). Urban land uses occupy the lower portion of the watershed, transitioning above the village to orchards, wholesale nurseries, and rural residential use. The unincorporated town of Soquel and the City of Capitola, both located near the mouth of the creek, are centers of urban and recreational activities within the watershed. Human density in the lower areas of the watershed is relatively high with a mixture of urban and suburban land uses, including light industrial and service areas. The Soquel Creek Water District provides these communities with potable water and Santa Cruz County provides wastewater treatment. Residents in

much of the remainder of the watershed use wells to extract groundwater and underflow for potable water and septic systems to treat wastewater.

FIGURE 2: WATERSHED LAND USE



Source: Santa Cruz County Assessor's Land Use Codes

The majority of the middle and upper watershed is occupied by rural residential use, along with a portion of the Forest of Nisene Marks State Park, small-scale agriculture (tree farms, orchards and vineyards), and a granite quarry that has operated for many years. Some commercial stables are present and many landowners have horses on their property. Also in this part of the watershed is the Soquel Demonstration State Forest, which is managed by the California Department of Forestry and Fire Protection for forestry education and research, watershed protection, public recreation, and demonstration of sustainable timber harvesting. Periodic logging has been conducted in the middle and upper watershed since the mid-nineteenth century. Several large acreages of relatively undeveloped private forest land which are managed for timber production comprise roughly 15 percent of the watershed. Based on timber harvest permit records over the past ten years, on average, timber harvesting during any given year has amounted to about 1% of the total watershed acreage.

Undeveloped areas within the watershed also include a portion of the Forest of Nisene Marks State Park, administered by the California Department of Parks and Recreation. Roughly 25% of the upper reaches of the creek and its major tributaries emanate from state land made up of two large parcels with extensive open-space holdings supporting grasslands, mixed woodlands, redwoods, and chaparral.

Table 2: Summary of Land Use in Soquel Watershed

Land Use Type	Number of Parcels	Area (Acres)	Percent by Area
Agriculture	22	447	1.7%
Commercial	294	225	0.8%
Government/Institutional	61	283	1.1%
Industrial	16	302	1.1%
Open Space (easement property)	11	262	1.0%
Parks and Recreation Facilities	96	3,766	14.2%
Residential	3,501	1,166	4.4%
Rural Residential/Misc Improvements	1,768	8,727	32.8%
Timberland	43	6,094	22.9%
Vacant/ Undevelopable	210	132	0.5%
Vacant/ Developable	721	5,107	19.2%
Other	49	76	0.3%
Total	**6,792**	**26,587**	
Total Streamside parcels	**682**		
Undeveloped Streamside Parcels	**174**	25.5%	

Source: Santa Cruz County Assessor Land Use Codes

Future Land Use and Flood Management Considerations

While steelhead are still distributed broadly, anticipated growth in housing and other population-related development may have an adverse affect on salmonid spawning and rearing habitat unless comprehensive solutions are implemented. Many existing and potential adverse effects can be minimized by implementation of common Best Management Practices (e.g., erosion-proof road construction) and conventional restoration projects (e.g., fish-passage improvement). However, Best Management Practices and restoration projects cannot completely mitigate cumulative impacts of new development resulting in increased water use and increased demand for flood management, including management of large woody material. Ultimately, development is regulated by the County of Santa

Cruz, which conducts prepares land use plans and zoning, conducts environmental review and approves permits for development in the area. Ten percent of watershed parcels are vacant but developable. Although 25% of the streamside parcels are still vacant, some of these may be constrained by floodplain designation, small size steep slope and/or septic constraints.

Although there may be some increase in water use in the upland rural areas, new development and new water extraction is limited by low density zoning and the limited amount of surface flow available for new residential uses. Stream flows in portions of the Soquel Creek watershed are currently fully appropriated during the critical low-flow season (SWRCB 1998). The groundwater resources that would be tapped to serve new development in the urban areas are already recognized to be depleted, which is most likely contributing to current depletion of streamflows. New water projects will need to be developed that reduce impacts on baseflow and provide water for existing and new uses. Although present criteria necessary to support new water right applications are more protective of coho salmon and steelhead habitat, monitoring compliance with existing and potential future bypass terms is politically and logistically difficult. Impaired base flows in many stream reaches are now - and likely will remain - inadequate to support viable southern coho salmon populations and perhaps steelhead populations, unless comprehensive water storage and distribution is provided and effective bypass monitoring and enforcement is institutionalized.

The Federal Emergency Management Agency (FEMA) has developed analytical procedures necessary to address flooding issues that may arise from restoration of coho salmon and steelhead habitat through the installation of large woody material, and local county planning departments are required to assure that these procedures are followed. Flood-prone areas in many urbanized coastal areas are mapped by the Federal Insurance and Mitigation Administration's Hazard Mapping Division, a division of the FEMA, and flood insurance rates are based on these maps. The Division updates National Flood Insurance Program maps as necessary to revaluate existing and proposed changes in floodway, and any project proponent is obligated to use standard engineering methods to describe likely project effects on flood levels. If adverse effects are predicted, then mitigations (e.g., removal of proposed developments on affected floodplain or modification of the channel to increase additional floodway capacity) must be incorporated.

Many channels in the Soquel Creek watershed are designated by FEMA as “A” type special-hazard floodways. Approval to install structures for enhancement of instream habitat (e.g., large woody material) into those stream reaches would thus require completion of very detailed topographic surveys, detailed analyses of bed load, analyses of collected data using hydraulic models, and a substantial public disclosure processes (independent of CEQA). Thus, although restoration of degraded habitat is necessary to support viable coho salmon and steelhead populations in the watershed, enhancement of many stream reaches using instream manipulations would be an exceptionally costly and time-consuming process. A better long-term plan is to retain more wood in the stream after natural inputs occur from large storm flows. This would require the reversal of activities focused on cutting up large wood that has accumulated. Retention of more large conifers growing adjacent to stream channels will also increase large wood recruitment.

OTHER SOQUEL CREEK WATERSHED ENHANCEMENT AND STUDY EFFORTS

Pertinent efforts to date have focused largely on estimation of juvenile steelhead relative abundance, water quality sampling, and the creation of education materials and programs supporting these efforts. Those efforts include:

- SOQUEL COORDINATED RESOURCE MANAGEMENT AND PLANNING (CRMP) OR SOQUEL WATERSHED GROUP. During 1995, a broad group of stakeholders was organized, with a steering committee of 12 landowners. The CRMP was organized under the auspices of the Santa Cruz County

Resource Conservation District, which has produced much literature, sponsored many workshops, and consulted with private landowners regarding information about drainage, erosion control, and protecting the county's waterways. As of late 1995, the Soquel Watershed Group's efforts were as follows:

- Adoption of a vision statement
- Development of a list of resource issues
- Preparation of a draft "Plan of Action"
- Completed a workday planting riparian species along Soquel Creek
- Conducted a day-long workshop on stream care
- Planning of a workshop on "Survival Strategies for Hillside Living"

- SOQUEL DEMONSTRATION STATE FOREST STUDIES. Numerous studies have been conducted in the Demonstration Forest, including an East Branch Watershed Assessment (1993); various biological, archaeological, and geologic assessments; Environmental Impact Report for the SDSF General Forest Management Plan (1995); water temperature and steelhead monitoring; and, aquatic macro-invertebrates monitoring. With assistance from the University of California Berkeley, the rates of input and flux, residence times, size distribution, and effects on channel form and habitat due to large wood in Amaya Creek and the East Fork of Soquel Creek has been documented. The data has been put into a GIS database with particular attention to identifying bottlenecks for large woody material transport. Review will include identification of measures to permit passage. Final products, expected in early 2003, will include (1) a GIS network model simulating large woody material movement through the watershed based on the sizes of wood, rates of wood supply to the channel, rates of downstream transport, and effects of human infrastructure, (2) a report summarizing observations of large wood movement into the stream resulting from buffer strips of various widths and recommendations for potential bridge and culvert replacements relative to existing costs of ongoing and emergency debris removal from structures, and (3) recommendations for planning tangible measures to allow movement of wood during storms and its retention for habitat between storms.

- SOQUEL LAGOON MANAGEMENT PLAN UPDATE. The *Soquel Creek Lagoon Management Pla*n was completed in 1990 for the City of Capitola and California Coastal Conservancy. The City of Capitola is in the process of updating this plan to provide continued protection and enhancement of fisheries resources of the lagoon. The lagoon is a very productive and reliable nursery ground for juvenile steelhead, despite its warm summer water temperatures. Sandbar construction, water quality conditions and juvenile steelhead and tidewater goby populations have been monitored in the lagoon since 1990. Other efforts conducted as a part of the lagoon enhancement plan have included interpretive signs and lagoon and watershed educational units.

- SOQUEL CREEK STREAMSIDE CARE GUIDE. In 1992 the City of Capitola produced a 32-page guide that was jointly prepared by the Santa Cruz County Chapter of the California Native Plant Society, the Santa Cruz Bird Club, and D.W. Alley & Associates with funding from the Coastal Conservancy and the City of Capitola.

- SOQUEL CREEK TASK FORCE. The limited scope of the Soquel Creek Task Force, organized by Capitola City Council Member Dennis Norton and endorsed by the Capitola City Council in the spring of 1999, was to identify major problem areas facing Soquel Creek, suggest possible solutions to those problems, and spearhead vehicles for implementation of solutions. The Task Force members donated about 15 hours to this effort. They conducted a public seminar series (the first of which was televised by CTV in Santa Cruz) and produced a brief summary and suggestions for action by the Capitola City Council.

- SOQUEL CREEK WATER DISTRICT INTEGRATED RESOURCES PLAN. Planning process established by the

Soquel Creek Water District to evaluate water supply demands and alternative sources to meet demand.

- SOQUEL CREEK WATER DISTRICT STEELHEAD MONITORING. The Water District conducted annual monitoring of juvenile steelhead production and habitat conditions throughout the watershed, upstream of the lagoon for the years 1994 and 1997-2002.

- SOQUEL CREEK WATER DISTRICT / COUNTY OF SANTA CRUZ SHALLOW GROUNDWATER MONITORING. The County of Santa Cruz and Soquel Creek Water District, in cooperation with local property owners, are collaborating in a three-year study of the interrelationship between seasonal stream levels and shallow groundwater levels along lower Soquel Creek. In 2002, five shallow monitoring wells (depth < 30 feet) were installed at monitoring sites alongside the stream channel over a four-mile reach of lower Soquel Creek. Monthly measurements of stream water levels and groundwater levels are being made at each site by SCWD technicians. A continuous data logger is also being used to collect data from select monitoring wells. These data can be plotted and evaluated to determine such things as the hydraulic connection between surface and groundwater, reaches where the creek may be losing or gaining flow to groundwater, and how creek levels may be affected by groundwater pumping.

- LOWER SOQUEL VALLEY WATER USE STUDY: The County is compiling information on surface and groundwater use in the lower Soquel Watershed by plotting and analyzing information on well location, well depth, land use, projected water use, stream diversions and water rights. This information will be used to better inform water resource management efforts in the lower watershed, with the ultimate objective of preserving and enhancing stream baseflows.

- EROSION PREVENTION PLANNING PROJECT FOR SANTA CRUZ COUNTY ROADS AND ROADS IN THE SOQUEL DEMONSTRATION STATE FOREST. The Soquel road assessment process consisted of the following project elements: 1) a field inventory of all stream crossings and ditch relief culverts on the County maintained roads in the Soquel Creek Watershed, 2) a comprehensive inventory of all stream crossings on the County maintained roads with 3' x 1' channel dimensions or a stream crossings with 24" diameter culvert or greater in the Soquel Watershed, 3) a complete inventory of all potential future road-related sediment sources along 18.2 miles of Soquel Demonstration State Forest roads 4) data base analysis to evaluate road segments and prioritize site specific treatment, 5) preparation of a final report of findings that outlines a prioritized restoration plan that can be used either to directly implement some or all of the recommended improvements, or to apply for grant funding for implementation.

WATERSHED CONDITIONS

This section provides an overview of existing conditions in Soquel Creek and factors that affect fishery habitat. Specific watershed assessment findings are provided in the following section.

GEOMORPHOLOGY AND HYDROLOGY

Geomorphology

The Soquel Creek watershed consists of three distinctive geologic blocks separated by the San Andreas and Zayante fault zones. The region has been subjected to tectonic uplift – and continuous erosion – since approximately 4 to 6 million years ago, mainly with the San Andreas fault, and also with relative vertical motion between the major structural blocks. Rates of uplift approaching 0.5 mm per year – or about one foot per 600 years – have been computed based on existing data and available field evidence. This rate is high relative to other rates of uplift reported elsewhere in the world, and many other segments of the Central California coast.

Nearly all reaches of Soquel Creek and its main tributaries flow in valley floors of alluvium. Alluvium is sediment deposited by streams, and is generally the parent material of the richer valley-bottom soils supporting riparian vegetation. Alluvial sediments have important watershed functions in that the materials also help store and convey ground water and modulate the supply of sediment from upstream or upland sources.

Rapid uplift, deep valleys and seismic activity in relatively weak rocks mean that landsliding and other forms of mass wasting are an intrinsic process by which sediment and wood enter the streams of the Soquel watershed. Landslides[1] and other processes of rapid downslope movement are frequent, extensive, and often large. They are especially prevalent in the two geologic blocks north of the Zayante fault, but do occur in steep terrain throughout the watershed.

The distribution and activity of the major fault zones has contributed to the large number of landslides and their scale in the Soquel Creek watershed. The East Branch has eroded its uniformly steep-sided valley along the axis of the San Andreas fault zone, is being uplifted more rapidly, and has been disturbed recently by the Loma Prieta earthquake. All bedrock units – sandstones, shales, and mudstones -- within the upper portion of this sub-basin have a recent history of slope failures.

Material delivered to the channel during tectonic and landslide events is eventually distributed downstream by fluvial processes to be either deposited on the bed, high-flow bars, and floodplains, flushed through the system to the Monterey Bay or, in the case of wood, jammed behind bridges or natural constrictions only to be washed from the alluvial corridor in the weeks (or seasons) following delivery to the channel. In all, tectonic uplift[2], mass movement of slope materials, and fluvial processes are the primary geomorphic processes shaping today's channels.

Stream Baseflows

[1] Landslides in this plan is used informally, and refers to all forms of mass wasting, also including mudflows, mudfloods, earthflows, creep, and other slope failures. No information specific to any given site or failure is implied.
[2] And associated lateral movement

Streamflows in Soquel Creek have been monitored since 1951 at a location on the eastern fringes of Soquel village. Since monitoring began, the range of annual baseflow values recorded has been variable. Annual departure data exhibit both strong year-to-year variability as well as extended periods of wet and dry cycles. Following the decade of the 1950s, annual minimum baseflows decreased by roughly 2 to 4 cfs such that the minimum summer baseflows from 1960 through present have ranged from 0 to 2 cfs.

Gaining and losing reaches have been identified along the mainstem and lower mainstem, and the hydrologic process can be variable depending on antecedent rainfall conditions. Gaining reaches are those that experience a net increase in streamflow as a result of groundwater discharge to the creek. In losing reaches the streamflow declines as water from the stream seeps out into underlying alluvium and groundwater aquifers. From June 1st through September 30th for the period 1984 to 1995, gaging records indicate extended periods of net surface water loss (recharge) to the alluvial sediments underlying the channel from the East and West Branch confluence downstream to the USGS gage. These periods of net surface water loss were identified during water years 1985, 1989, 1990, 1991, 1992 and 1994. During the same general period, the gaging records also indicate extended periods of net surface water gain (ground-water discharge) in Soquel Creek from the confluences to the USGS gage location. Periods of net surface water gain were identified during water years 1984, 1986, 1987, 1993 and 1995.

Channel Stability and Geomorphic Characteristics

The position of the Soquel Creek channel has remained fairly stable since the 1955 flood with two major exceptions at stream mile 2.7 and 7.8. This stability is due to steep valley walls in the upper watershed and bedrock constraints and incised channel geometries in the lower watershed (in general). Along the mainstem of Soquel Creek, vertical channel stability since the 1955 flood has been spatially variable with some reaches recording aggradation and others recording degradation.
Work completed for the current assessment indicates that the USGS gage site has recorded general downcutting since 1956.[3]

The channel reach through the USGS gage at Soquel has recorded an overall pattern of net channel degradation of roughly 2.25 feet since 1960. Short periods of net aggradation occur within the overall pattern of degradation. Historically, lateral channel adjustment has occurred primarily at points of meandering or where land use had reduced the extent of riparian vegetation buffering the active channel from the adjacent floodplain.

Bed Conditions and Sediment Discharge

Sediment covering bars in the headwaters and along the mainstem of Soquel Creek ranges in size. This size range is smaller than that measured in the upper Carmel River watershed following the 1977 Marble Cone fire and roughly approximated by data collected in Zayante Creek at Graham Hill Road in 1996. The Zayante data represents chronic sedimentation conditions in that watershed.
Due to the affects of past and historic episodic events, large reserves of sediment are available for transport to lower reaches in the East Branch, West Branch, and mainstem of Soquel Creek. This is significant over the lifetime of any implemented project because there is a potential for future bank destabilization due to bed aggradation as pulses of sediment move through the system. Retention of naturally recruited large wood material in the stream channel would help to modulate sediment transport downstream, thereby buffering the impact of any large 'sediment pulse' and also perhaps aiding in preservation of habitat because of the structural element of wood. Permits necessary to

[3] Degradation is the geologic process by which streambeds and floodplains are lowered in elevation by the removal of material. It is the opposite of aggradation in which the streambed and floodplain are deposited with sediment

implement most wood placement projects would require substantial and sophisticated analytical work, and it is likely that wood placement projects would be meet with resistance from streamside property owners as well as downstream residents.

Sediment Sources

Many large, discrete sources of sediment exist in the East Branch and West Branch of Soquel Creek with perhaps the most notable of these being the 'Highland Way' landslide which occurred in January 1997. These sources of sediment generally result from landsliding due to seismic shaking and intense rainfall events. It should be clear, however that older (remnants likely of the most recent Ice Ages) and larger slides present in the upper East Branch will be reactivated by seismic shaking and intense rainfall in the future.

A study prepared for RCD and the California Department of Fish and Game also documented sedimentation in the Soquel Creek watershed as a result of rural roadways (Pacific Watershed Associates, June 2003). Observations indicate that roads have been, and continue to be, a significant source of accelerated sediment production and delivery in the watershed. The study identified stream culverts and road segments with future erosion potential and recommended treatments to prevent erosion, many of which are associated with stream crossings and potential plugged culverts. This assessment did not investigate other potential present sources of sediment in the watershed. Work in neighboring San Lorenzo River and Aptos Creek Watersheds has shown that roads and landsliding associated with roads contribute the majority of anthropogenic sediment.

RIPARIAN VEGETATION

The California Department of Fish and Game describes the riparian zone as the terrestrial component of the stream environment and defines riparian vegetation as "any extra-aquatic vegetation that directly influences the stream environment." Riparian zones are typically subject to partial or complete flooding, and riparian vegetation is adapted to constant renewal within a dynamic ecosystem. Storm flows scour existing vegetation and deposit sediment, creating exposed areas of moist substrate and an opportunity for seeds of moisture-adapted species (such as alders and willows) to become established and grow back rapidly until the next large flood event washes them out.

Riparian tree species are usually identified as the broad-leaved deciduous species that naturally occur only in proximity to water. These species can tolerate anaerobic conditions in their root zone for extended periods of time and are "phreatophytic" that is capable of taking moisture directly from the water table or from the capillary fringe above the water table. Where proximity to water is limited because the streamside topography slopes steeply upward from the channel, upslope vegetation dominated by conifers and broadleaved evergreens may also functionally be part of the riparian vegetation.

Riparian vegetation performs several functions that are essential for a healthy fish habitat: it supplies nutrients, cycles nutrients, contributes to spawning and rearing habitat, and provides shade to keep the water cool.

- NUTRIENT SUPPLY. Leaves falling into the water provide nutrients directly to aquatic organisms, especially invertebrates, and form the basis for the aquatic food chain. Riparian vegetation contributes nutrients indirectly by way of insects, moss, lichens, and bird and insect droppings that fall into the water from overhanging branches.

- NUTRIENT CYCLING. Riparian vegetation takes up nutrients from the stream and cycles them back

into the forest by way of its foliage.

- SPAWNING HABITAT. The roots and foliage of riparian vegetation protect soil particles from detaching from streambanks, reducing inputs of fine sediment that bury spawning gravels. Fallen vegetation on the forest floor of streamside slopes forms a protective blanket that reduces erosion, filters sediment, increases water clarity, and improves spawning habitat. Woody material in the creek captures and immobilizes sediment, further contributing to water clarity.

- REARING HABITAT. Large woody material that comes to rest in the stream channel creates pools and escape cover for fish. Overhanging shrubs provide additional escape cover near the banks. The roots of vegetation within and beyond the stream corridor keep the soil porous, increasing infiltration, reducing the flashiness of storm runoff, and increasing base flows during the dry season. Perhaps most importantly, the canopies of trees and shrubs shade the water and keep it cool so that the metabolic rate of salmonids stays within the limits of the available food supply, which consists chiefly of aquatic macro invertebrates.

Riparian vegetation affects steelhead/salmon habitat due to the influence of vegetation on water temperature, the makeup of native riparian vegetation, and infestation of native riparian vegetation by invasive exotic (i.e. non-native) plants.

- SHADE AND WATER TEMPERATURE. Water temperatures affect the quality of aquatic habitat for steelhead and coho because fish are cold-blooded organisms, and increased water temperatures increase their metabolic rate. Shading by riparian vegetation provides a cooling influence to the creek and buffers it from solar warming. The most direct measure of shade is canopy closure. Other factors in the creation of *shaded riverine aquatic habitat* (SRA) include tree height (taller trees cast longer shadows than shorter trees), canopy angle (shadows of tall trees may not shade the creek if the trees are located a distance from the channel, whereas trees of moderate height may provide significant shade if they are located next to the low flow channel; and total width of the channel (portions of a broad channel may be beyond the reach of any shading influence).

- COMPOSITION OF TREE SPECIES AND SIZE CLASS DISTRIBUTION. Tree species contribute in different ways to salmonid habitat. Deciduous trees contribute a pulse of nutrients when their leaves drop in the fall, while conifers are the tallest trees along Soquel Creek and create the greatest amount of shade. They also attain the largest trunk size, making them valuable as large woody material in the stream, and conifers last longer in the water than hardwoods. In turn, the larger hardwoods (Sycamore) last longer in the water than smaller ones such as alder and willow.

- INVASIVE EXOTIC PLANTS. A number of detrimental effects are caused by invasive exotic plants in riparian corridors that typically produce a dense cover, which suppresses recruitment of riparian trees, reduces the species diversity of the native vegetation, and may cause decline of the forest canopy as recruitment declines. Their rapid growth shades slower growing native plants in the understory.

The major riparian tree species are represented by a full array of size classes along Soquel Creek; small trees are numerous and recruitment is active. The tallest deciduous riparian trees, the sycamores and cottonwoods, are generally located on terraces well above the bed of the creek where they became established following heavy flow events. From the ocean to Soquel Village, the width of the riparian forest seldom extends beyond the top of the bank. Upstream from the village, scattered but significant portions of the riparian vegetation remain relatively intact. Invasive exotic plants are found in all reaches of the creek, with no particular location containing significantly more or less than

others with the exception that invasive exotic plants are more abundant in the understory than in the canopy.

FISHERIES

In-stream Habitat

Each summer since the 1950's, a sandbar is constructed by the City of Capitola at the mouth of Soquel creek and operated to form a freshwater lagoon. The lagoon provides a warm but very productive, reliable nursery ground for large, fast-growing juvenile steelhead. Estimates of steelhead abundance in the summer lagoon have ranged between 250 and 2,800 juveniles per year since 1993. A unique concrete flume that passes through the sandbar is used to regulate water level in the lagoon. Construction of the sandbar and operation of the flume is regulated by the California Department of Fish and Game, Army Corps of Engineers, and California Coastal Commission.

The lower mainstem between the lagoon and Moores Gulch provides habitat for low densities of relatively fast growing juvenile steelhead. Spawning conditions are more stable during mild winters, particularly if storms occur primarily early in the wet season. However, young-of-the-year steelhead grow more rapidly in years with higher baseflow, and a higher proportion reach smolt-size after one growing season. Juvenile steelhead densities generally increase above Moores Gulch and into the East Branch through the Soquel Demonstration Forest, as the adjacent coniferous forest increases and the stream meanders through more canyon-like terrain with high vertical bluffs.

The East Branch flowing through the Soquel Demonstration State Forest (SDSF) is the primary spawning grounds for steelhead in the watershed. The highest densities of young-of-the-year and yearling steelhead occur in the SDSF. In the lower West Branch, downstream of Hester Creek, juvenile steelhead densities are typically low and growth rate is slow. Hester Creek is a major source of sediment.

- ADULT SALMONID PASSAGE. Passage impediments in Soquel Creek have the greatest impact on migrating adult salmonids heading to spawning grounds. Access to spawning habitat is especially limiting when streamflow is insufficient to provide adequate water depth for passage over waterfalls or through steep or wide, shallow riffles. If sufficient flows do not remain long enough, adults cannot reach the upper branches and (thus) the best spawning habitat. Adult fish passage will become more difficult as increased urbanization tends to cause storm flows to become more flashy with a rapid increase in flow followed by a rapid decrease in flow

  Since passage over many potential barriers is flow dependent, and coho salmon migrate upstream and spawn in late fall and early winter sometimes before significant storm flows, they are much more vulnerable to passage impediments than steelhead. Coho salmon are also weaker swimmers and jumpers than equally sized steelhead.

- SMOLT OUT-MIGRATION. Smolt out-migration by both coho salmon and steelhead occurs primarily from March through May. The primary limiting factor on movement of smolts from rearing habitat to the ocean is passage across critically wide, shallow riffles. Critical riffles are stream reaches where water depth is too shallow for fish passage, and these riffles can be of natural or anthropogenic origin. Complete de-watering of the channel can occur during drought. In 1992 and 1994 the channel went dry in the lower watershed near the Walnut Street Park.

WATERSHED ASSESSMENT FINDINGS

ASSESSMENT METHODOLOGIES

Assessment findings and recommendations were developed through an interdisciplinary approach that included review of geomorphology, hydrology, salmonid fisheries habitat and conditions and distribution of riparian vegetation. Each assessment included historical data review, field studies, data analysis, and data synthesis. Specific field assessments that were conducted are summarized below.

Hydrology and Geomorphology

The primary objective of this assessment was to describe historic and present-day hydrologic and geomorphic conditions in the Soquel Creek watershed, both within the watershed and within specific reaches, to help address whether these conditions have been or currently are limiting salmonid populations. Specific areas reviewed included physical stream characteristics (pattern, channel and bed conditions, stability), sediment transport, and stream flow and hydrological issues, including whether there is a hydraulic connection between underlying bedrock and stream channel deposits. Installation of two new temporary stream gages and measurement of riparian canopy width along the banks were included as part of the assessment.

Riparian Vegetation

The riparian vegetation assessment was conducted to determine whether the forest along Soquel Creek is in a healthy condition, and to what extent it currently contributes benefits to the instream habitat for fish. The assessment focused on: a) the factors affecting shading of the low flow stream channel, b) the composition of the riparian vegetation as determined by tree species and size class distribution, and c) the extent and distribution of invasive exotic plants. In addition to review of existing data, the assessment included field surveys that consisted of walking approximately twelve miles of the creek and portions of the tributaries, and establishing transects every 1,000 feet. At each of 60 transects an array of measurements was recorded and a forest inventory was conducted to census trees (greater than 6 inches, measured from breast height diameter [dbh]) in a 60-foot radius plot.

Fisheries

The fisheries assessment reviewed existing data and included supplemental field work that addressed factors critical to habitat conditions and life stages for coho salmon and steelhead. This work included review of water temperature, particle size as it affects spawning conditions, presence of large woody material, streambank erosion, and impediments to fish passage. Field work included measurements and/or analysis of water temperature, erosion/landslide features, particle size for spawning habitat, and identification of potential fish passage impediments.

GENERAL WATERSHED FINDINGS

Geomorphology

- Soquel Creek has experienced prolonged periods (up to 25 to 30 years) of disturbed watershed conditions over the past 150 years. These conditions were caused by both natural processes (i.e., earthquakes, major storm events and droughts) and human activities (primarily logging from about 1870 to 1942) with the latter likely resulting in an increase in the natural, base rate of sediment production in the watershed, although small relative to natural rates. Impacts to channel and riparian conditions from major storm events of the 1940s and 1950s were more long-lasting and possibly severe than impacts to the channel from the January 1982 storm, the drought of 1987-1992 and the 1989 Loma Prieta earthquake.

- The channel reach through the USGS gage at Soquel has recorded an overall pattern of net channel degradation of roughly 2.25 feet since 1960. Short periods of net aggradation occurred within the overall pattern of degradation. From 1954 through 1975, sediment had accumulated on the streambed, although gradually diminishing throughout this sub-period.

  Channel bed aggradation at the USGS gage in the mid to late 1950s is thought to be a result of cumulative long-term impacts from large-scale forest harvesting up to 1942 in the East Branch; the drought in 1944 to 1950; the occurrence of moderate to high flood flows from 1951 to 1953; the peak flood in December 1955; and the period of moderate flood flows immediately following the peak event from water years 1957 through 1960.

  From 1975 through 1990, the summer streambed was fairly stable with a small amount of net aggradation having occurred during the last three years of this sub-period. From 1991 through 2002, one short period of net aggradation occurred from water year 1993 to 1994 followed by net degradation through 2002. The Loma Prieta earthquake in 1989 resulted in net aggraded channel conditions at the USGS gage during water years 1994 and 1995. Reaches upstream of the gage likely experienced similar conditions in the years after the earthquake yet before 1994.

- Historic, lateral channel adjustment has occurred primarily at points of meandering or where land use had reduced the extent of riparian vegetation buffering the active channel from the adjacent floodplain.

- Exposed channel width has decreased at nearly all measured stations between approximately 1955 and 2002.

- Sources of sediment in the watershed included primarily landslides (over 20 documented) entering the creek channel in the upper East Branch (upstream of Ashbury Gulch), Amaya Creek, Hester Creek, Burns Creek (Santa Cruz County Study, 1986), Laurel Creek (Santa Cruz County Study, 1986), Grover Gulch and the upper West Branch (upstream of Girl Scout Falls II). Wood clusters were often associated with the toe of landslides and sometimes stored considerable sediment.

- Measured rates of suspended and bedload sediment transport in water year 2002 were lower than rates measured during water years 1990 through 1993. Although somewhat sparse, during both periods of monitoring, rates of bedload transport were well below theoretical 100% efficiency transport rates for the USGS gage site.

- Although major sediment production is likely most pronounced during an earthquake, large magnitude flood or forest fire, chronic sources of sediment are active in between large events and are problematic in the Soquel Creek watershed, contributing to fine sediment in spawning gravel and rearing habitat. Based on road assessment work in Soquel and neighboring watersheds, likely sources of chronic fine sediment are primarily public and private roads, with other land disturbances playing a secondary role.

Hydrology

- Baseflows have decreased since the 1950s by roughly 2 to 4 cubic feet per second (cfs), resulting in longer periods of low baseflows. The amount of time with baseflows between 0 and 2 cfs was 16 days in the 1950s, 492 days in the 1980s, and 413 days in the 1990s. This is significant if it is determined that the flows between 0 to 2 cfs are limiting to fishery and vegetation through the lower mainstem. Baseflows are affected not only by precipitation and infiltration amounts during the previous rainy season, but also by those of the prior one (or sometimes two) winters, as well as diversions, pumping and riparian evapotranspiration. Increased evapotranspiration from forest regrowth after the clear cutting prior to the 1950s may also be contributing to lower baseflows.

  The recorded decrease in minimum baseflows during the 1960s is likely less accounted for by aggraded stream conditions than other factors because of the similarity in channel bed conditions between the 1950s and the 1960s. The recorded decrease in minimum baseflows during the drought of 1976 and 1977, during water years 1978-1979, 1981, 1985, 1987 and 1992-1993 cannot be explained satisfactorily by channel bed conditions at the USGS gage because the channel bed was gradually downcutting to historic low levels over the past 50 years. The recorded decrease in minimum baseflows from water years 1988-1991 and 1994 could be partially accounted for by slightly aggraded channel conditions at the USGS gage. Cumulative precipitation conditions in the region were similar for the 1950s, 1960s, 1970s and the drought period 1987-1994 (based on a record length 1942 to 2001).

- From June 1st through September 30th for the period 1984 to 1995, gaging records indicate extended periods of net surface water loss (recharge) to the alluvial sediments underlying the channel from the confluences downstream to the USGS gage. These periods of net surface water loss were identified during water years 1985, 1989, 1990, 1991, 1992 and 1994. During the same period, the gaging records also indicate extended periods of net surface water gain (ground-water discharge) in Soquel Creek from the East and West Branch confluence to the USGS gage location. Periods of net surface water gain were identified during water years 1984, 1986, 1987, 1993 and 1995.

  During summers, flows will vary along the course of any stream. The reach from the East-West Branch confluence to the USGS gage is both a surface flow gaining and losing reach with periods of loss closely linked to years of below long-term average rainfall. The reach from the USGS gage to Walnut Bridge (SQWB) was a losing reach during the summer months of 2001 and 2002. This segment of the stream may be a chronic losing reach, based on a number of isolated measurements by others during prior seasons. The reach from the Walnut Bridge (SCWB) to Nob Hill could be a gaining reach, however only one measurement from water year 2002 can substantiate this hypothesis. Additionally, County staff report that baseflows tend to increase slightly from SQWB to the Nob Hill reach, immediately upstream of the lagoon at the mouth of Soquel Creek.

- Shallow hydraulic connectivity between overlying alluvium and underlying Purisima members exists along the mainstem of Soquel Creek with connectivity diminished at the contact and in

the vertical column when 'silty' lenses of material are present. The depth of the contact along the mainstem likely varies from 40 to 60 feet, but its geometry and properties are not adequately known nor is there a well-developed and generally-accepted conceptual model of the alluvial aquifer.

- During wet years, such as 1995, the stream gains base flow between (a) the two upstream gages on the East and West Branches and (b) the USGS gage on the main stem within the community of Soquel. Conversely, during normal and dry summers, Soquel Creek usually loses a small amount of flow between the two upstream and the downstream gages. Apparently short-term recharge of the Purisima system can result in higher baseflows. Long-term recharge rates as well as locations of recharge areas are central questions regarding the long-term enhancement and protection of low flows in the main stream courses of the Soquel stream system.

Riparian Vegetation

- Taken as a whole, the riparian vegetation along Soquel Creek is in a moderately healthy condition. In some of the less-urbanized locations, the streamside forest may currently be as wide as it was before 1840. Tree cutting is localized on numerous properties, but there are few long stretches where the streamside forest has been removed by land use activities. Shorter stretches of bank where vegetation has been cleared are located on a significant number of small and medium-sized parcels. Most of the longer treeless banks appear to be the result of natural forces combined with poor management of streamside vegetation.

- The forest inventory found a healthy assortment of native tree species, most of them represented by a full array of size classes. There is a gradual transition from dominance of deciduous trees downstream to dominance of evergreens in the upstream reaches. Alders and cottonwoods are abundant in the mainstem. Some maples and sycamores are present. Douglas-firs were found in all sections of the creek and were represented by all size classes. Redwoods were lightly distributed along the main stem, occurred more frequently in the east branch, and were dominant along the west branch and tributaries. Most willows occurred in the lower portion of the mainstem.

- There was little or no change in the total riparian canopy coverage from 1956 and 1985 in the Mainstem between the East-West Branch Confluence and Moores Gulch. However, a considerable decrease was measured in the Mainstem between Moores Gulch and Bates Creek, although one station recorded an increase in canopy width. Left bank measurements showed a similar trend to right bank measurements.[4]

- Canopy closure gradually increased with distance upstream. It was highest in the west branch and the tributaries. Canopy closure was uneven in the mainstem and east branch, with by far the lowest values being in the vicinity of a long stretch of riprap along the east branch. The low-flow channel was frequently located adjacent to one bank or the other, and was nearer to trees and in greater shade than if it were located at mid-channel. Topographic shade increased with distance upstream, as did the amount of shade provided by evergreen trees.

- There are numerous locations where the existing riparian vegetation is inadequate to contribute to healthy functioning of the creek due to lack of canopy coverage, although in many locations the riparian vegetation along Soquel Creek is in fairly good condition. Nearly

[4]Channel and riparian conditions following the January 1982 storm were very poor and similar to those for the December 1955 storm.

80% of the sites sampled had less shade than recommended by the California Department of Fish and Game for coho salmon rearing habitat.

- At locations where natural processes remove riparian vegetation, natural regeneration tends to replace the riparian vegetation. There are a few locations where the stream has historically migrated laterally, creating erosion and a broad, unshaded channel. In these locations trees are regenerating naturally and active tree planting may not be needed, although planting of trees and shrubs would increase the stability of the banks. Where riparian vegetation is removed by streamside residents, it usually is not allowed to regenerate.

- Invasive exotic plants are found in all reaches of the creek, with no particular location containing significantly more or less than others with the exception that invasive exotic plants are more abundant in the understory than in the canopy. Overall, Soquel Creek is less heavily invaded than more urbanized creeks elsewhere in central California, and Himalayan Blackberry *(Rubus discolor)* in particular is less abundant than it is elsewhere. Giant Reed *(Arundo donax)* occurs at six locations in Reaches 1-3 and is a high priority for prompt eradication; it spreads rapidly to clog waterways. English Ivy *(Hedera helix)* is a direct threat to riparian trees when it climbs into their crowns, because it weakens them by shading their foliage and its weight pulls them over. Broom and periwinkle (*Vinca major*) are also present at many locations.

Fisheries

- The East Branch flowing through the Soquel Demonstration State Forest (SDSF) is the primary spawning grounds for steelhead. The highest densities of young-of-the-year steelhead occur in the SDSF. However, juvenile growth rate is slow with low summer baseflow, requiring two years for fish to reach smolt size.

- Spawning gravel in glides with steelhead redds[5] was similar in quality to gravel in unused glides.[6] However, adult steelhead appeared to spawn upstream of steep, constricting riffles to maximize intra-gravel water velocity. In 4 of the 7 analyzed spawning redds, steelhead chose gravel with D-84 values much beyond the 90 mm (3 ½ inches) typical upper boundary for spawning gravel size. This may indicate that spawning gravel of preferred size at the heads of appropriate riffles (at least on the streambed surface) was in short supply in Soquel Creek. Higher densities of young-of-the-year steelhead in Soquel Creek in 2002 (as in 1997) were

[5]A redd is a salmonid spawning nest constructed in spawning gravel (1/2- 31/2 inches in diameter) typically located at the tail of a pool in a spawning glide that is situated just upstream of a steep, narrowing riffle. Riffles are steep, relatively shallow, fastwater habitats with considerable surface turbulence caused by water flowing around rough, coarse substrate often with exposed boulders and cobbles. Food for juvenile, drift-feeding salmonids is primarily aquatic insects that mainly inhabit riffles, along with adult insects that fall into the water from overhanging vegetation. In streams where pools lack suitable spawning glides or in larger streams with deeper runs and riffles, salmonids may spawn in less turbulent portions of riffles and runs (runs are deeper than riffles and less turbulent, though faster than glides and have more irregular bottoms).

[6]A spawning glide is habitat found at the tail of a pool, characterized by a relatively flat streambed, gradually shallowing depth in a downstream direction that encourages intragravel water infusion, even flow across the entire width and some resistance to scour. If the spawning glide is short, it is sometimes considered part of the pool habitat. If the glide is long, it is considered a separate habitat. Glides are present as the stream transitions from slow, deeper pools into shallow, faster riffles, and are situated just upstream of the hydraulic control for the pool above (hydraulic control is the high point on the streambed at the head of the riffle immediately below the glide).

likely due in part to higher egg survival and fry emergence resulting from less scour of spawning redds than other years during a mild winter without significant late storms.

- Steelhead mortality from egg to fry emergence was high in several spawning glides. The best estimate of average steelhead survival rate from egg to fry emergence was 49% in 2002. Thirty-five spawning glides were identified in 10 miles of the mainstem and East Branch (only 3.5 per mile) and only 10 glides had observable redds in 2002, a year when redds would be highly visible.

- There are numerous impediments and/or barriers to fish passage, primarily in the upper reaches of the watershed. Artificial absolute passage barriers are a concrete Laurel Mill Dam abutment on the upper West Branch (approximately 6 miles upstream of the Hester Creek confluence) and the concrete dam on Bates Creek below the Grover Gulch confluence. Natural features creating impediments include two bedrock chutes on the West Branch, a bedrock shelf and 4 boulder fields on the East Branch, a bedrock chute and bedrock waterfall on Bates Creek, bedrock falls on Moores Gulch, bedrock falls on Hinckley Creek and wood clusters on other tributaries (Hester and Amaya Creeks).

- In the mainstem, downstream of the West Branch confluence, escape cover under objects (stumps, boulders, logs, etc.) in pool habitat in 2000 showed a third year of measured decline. In 1997 there were 3,701 linear feet of cover measured in pools, compared to 1,692 feet in 1999 and 1,602 feet in 2000.

- Large wood was extremely scarce in Soquel Creek compared to other coastal streams recently surveyed (Waddell, Scott and Gazos Creeks). While a high proportion of wood in the channel was greater than 2 feet in diameter and/or greater than 20 feet in length, it was mostly hardwood-derived and not contributing to habitat features apparent during the survey.

- Pools and backwaters formed by logs were primarily formed by relatively scarce, large (greater than 2 feet in diameter and 20 feet in length), coniferous wood, despite the fact that large hardwood wood was present in greater densities.

- Recruitment sources of new large wood were primarily perched, dead/standing and/or leaning trees, most of which are hardwoods less than 2 feet in diameter (in particular red alders and cottonwoods). Very few dead/standing or leaning conifers were present, and most of these were in riparian or upslope areas, where the likelihood of natural recruitment is low.

- Water temperatures for steelhead generally ranged from good in the upper watershed to limiting in the lower watershed. Water temperature in the mainstem, East Branch, and lower West Branch did not meet the tolerance limits for coho salmon.

REACH-SPECIFIC LIMITING FACTORS AND CONSTRAINTS

Summary

Several factors appear to limit distribution and abundance of steelhead. These factors include passage impediments, poor spawning habitat quality (high proportion of fine sediment, number of constricting, steep riffles below spawning glides), low spring and summer baseflows, limited amount of escape cover (provided by instream wood, undercut banks, unembedded boulders, water depth itself), elevated water temperature, and limited water depth. Throughout the watershed, low baseflows and sedimentation limit the amount and quality of rearing habitat. The same factors that limit steelhead also

limit coho salmon, although coho salmon are more sensitive to warmer water temperature. In this assessment the limiting factors have been summarized for different segments of the Soquel Creek drainage as shown on Table 3. The tables on the following pages summarize findings per watershed reach. Appendix A summarizes the locations of impediments to fish passage.

Watershed Resource Units

Seven reaches of Soquel Creek were classified into "resource units" (RU) according to the Montgomery and Buffington (1997) channel-reach morphology system; the reaches are illustrated in Figure 3. Table 4 contains resource unit classification by channel type and sediment function.

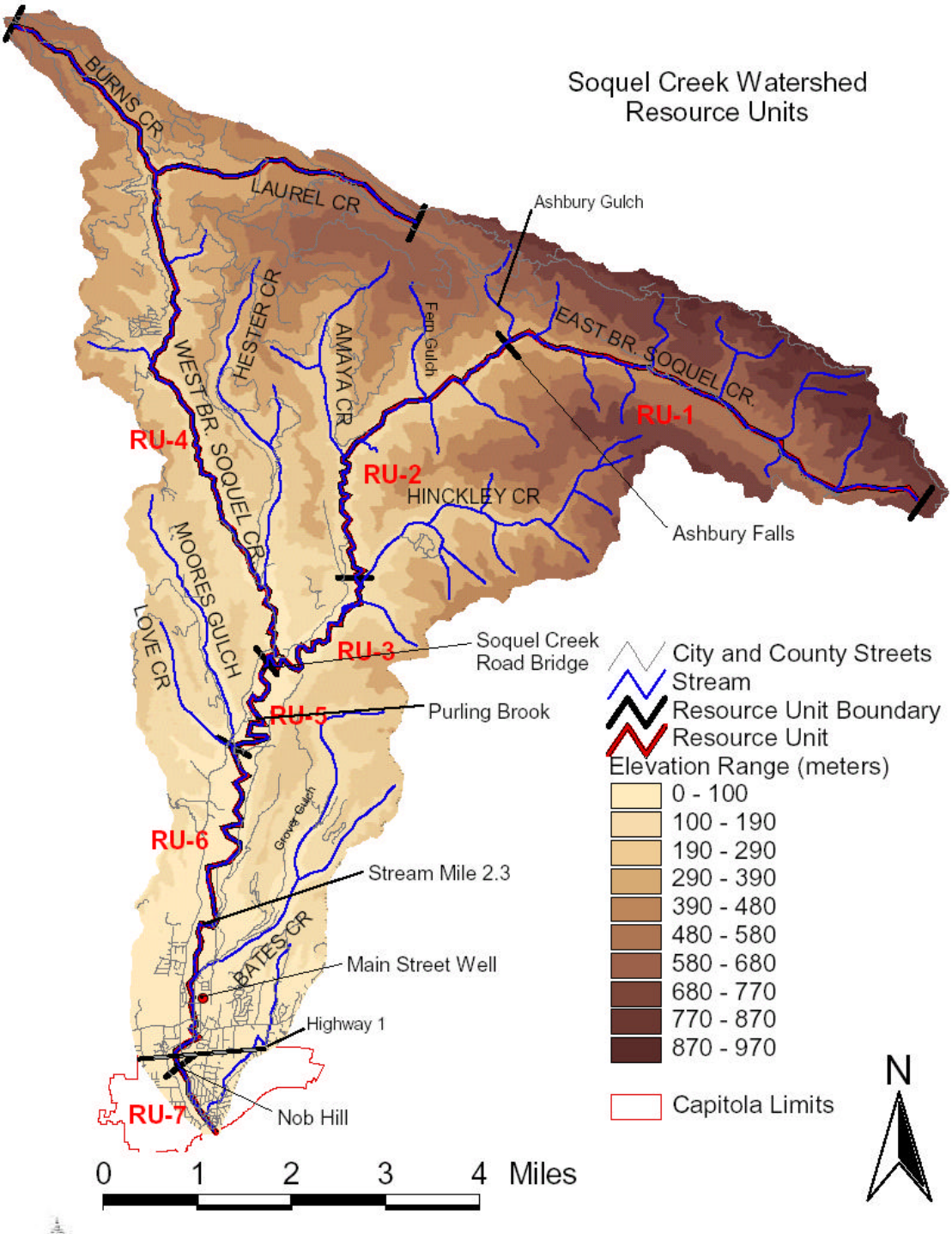
TABLE 3: LIMITING FACTORS FOR STEELHEAD AND COHO SALMON
SOQUEL CREEK MAINSTEM, BRANCHES AND TRIBUTARIES
(Factors limiting coho salmon are in parentheses if different from steelhead.)

Location	Sediment-Spawning	Sediment-Rearing	Adult Passage Impediments	Spring and Summer Streamflow	Summer Water Temperature	Large Woody Material
Lagoon	No	Yes	No	Yes	Yes	Yes
Mainstem to Moores Gulch	Yes	Yes	Yes- Drought Only	Yes	Yes	Yes
Mainstem from Moores Gulch to East-West Branch Confluences	Yes	Yes	No	Yes	No (Yes)	Yes
East Branch from West Branch Confluence to Hinckley Creek Confluence	Yes	Yes	No	Yes	No (Yes)	Yes
East Branch from Hinckley Creek to Canyon Mouth	Yes	Yes	No	Yes	Yes- Highly	Yes
East Branch from Canyon to Ashbury Falls	No	Yes	No	Yes	No (Yes)	Yes
East Branch from Ashbury Falls to the Soquel Demonstration State Forest Entrance	No	Yes	Yes	Yes	No (Yes)	Yes
West Branch from East Branch Confluence to Hester Creek	Yes	Yes	No	Yes	No (Yes)	Yes
West Branch from Hester Creek Confluence to Girl Scout Falls I	Yes	Yes	Yes- When Culvert in Ford is Obstructed	Yes	No (Yes)	Yes
West Branch from Girl Scout Falls I to Girl Scout Falls II	Yes	Yes	Yes	Yes	No (Yes)	Yes
West Branch from Girl Scout Falls II to Flashboard Dam	Yes	Yes	Yes	Yes	No (Yes)	Yes
Bates Creek	Yes	Yes	Yes	Yes	No	Yes
Moores Gulch	Yes	Yes	Yes- If Culverts Jam	Yes	No	Yes
Hinckley Creek	Yes	Yes	Yes	Yes	No	Yes
Amaya Creek	Yes	Yes	Yes	Yes	No	No
Hester Creek	Yes	Yes	Yes	Yes	No	Yes- Lower Reaches

TABLE 4: SOQUEL CREEK WATERSHED RESOURCE UNITS – SEDIMENT FUNCTION

Resource Unit and Reach Name		Channel Type	Sediment Function	Comments
Resource Unit 1	*Upper East Branch*	bedrock, cascade and step-pool	production	major production zone-mass movements
Resource Unit 2	*Mid East Branch*	bedrock, cascade and plane-bed	production and transport	major production zone, transition to transport zone
Resource Unit 3	*Lower East Branch*	plane-bed and pool riffle	transport and storage	channel structure can be highly influenced by logs and bedrock
Resource Unit 4	*West Branch*	bedrock, cascade step-pool and plane-bed	production and transport	major production zone which includes Hester Creek as a tributary
Resource Unit 5	*Upper Mainstem*	bedrock, plane-bed and pool riffle	transport and storage	channel structure can be highly influenced by logs and bedrock
Resource Unit 6	*Mid Mainstem*	bedrock, plane-bed and pool riffle	storage	channel structure can be highly influenced by logs and bedrock
Resource Unit 7	*Lagoon*	plane-bed and pool riffle	storage	Storage has been impacted and is largely restricted to bars

FIGURE 3: WATERSHED RESOURCE UNITS



Balance Hydrologics, Inc.

project: 200021.apr

Figure G-7: Soquel Creek Watershed Assessment Resource Units, Santa Cruz County, California

WATERSHED-WIDE FINDINGS AND LIMITING FACTORS	
HYDROLOGY & GEOMORPHOLOGY	
Streamflow	Over the past 50 years, baseflows have decreased by 2-4 cfs at the USGS gage during dry years. Baseflows can range from 0 to 1.99 cfs during dry years and 4 to 5.99 cfs during normal to wet years.
Lateral Channel Adjustment	Overall lateral channel stability of Soquel Creek was reasonably stable during the past 54 years with minor adjustment having occurred at several points of meander along the East Branch and mainstem.
Vertical Bed Adjustment	Vertical channel adjustment has been spatially variable over the past 54 years in the watershed with some reaches having aggraded while other reaches having degraded.
Sediment Sources	Major sediment production occurs in both the East and West Branches and is likely most pronounced during an earthquake, large magnitude flood or forest fire. Chronic sources of sediment are active in between large events and are problematic in the Soquel Creek watershed.
FISHERIES	
Spawning Habitat	Survival from egg to fry emergence limited young-of-the-year production in the mainstem and lower East Branch, with estimated survival as low as 27% and averaging 49% in glides used by adult steelhead in 2002. Spawning substrate was armored with large particles on the surface and averaged 27% fine sediment (<2mm) in the mainstem and lower East Branch.
Rearing Habitat	Limited by low baseflows, highly sedimented streambed, warm water, shortage of large wood. Juvenile growth rate was reported higher in years of higher baseflow in Soquel Creek, and a higher proportion of young-of-the-year fish reached smolt size in years withy higher baseflow in the mainstem.
Pool Habitat	Pool habitat was generally low in fish escape cover due to the shortage of large woody material, but was increasing as overhanging riparian vegetation has recovered since the El Niño winter of 1997-98.
Large Woody Material	The scarcity of large wood limited juvenile production throughout the watershed; movement of large wood restricted by culverts on tributaries.
Refuge Potential	The resource units currently with the highest refuge value are the mainstem (between the Moores Gulch confluence and the Branch confluences), West Branch (downstream of Girl Scout Falls I) and the East Branch (between the Soquel Creek Water District weir and Ashbury Falls). If passage impediments are modified, the upper West Branch above Girl Scout Falls I and II and the upper East Branch above Ashbury Falls will also be valuable refugia.
Passage Impediments	Impediments in the East and West Branches are more than 10 miles inland. Adult steelhead access to upstream spawning habitat may be limited when streamflow is insufficient to provide adequate water depth to allow passage over smaller bedrock chutes and waterfalls or through steep or wide, shallow riffles.
Passage Barriers / Extent of Anadromy	In nearly all years in most of the watershed, barriers to anadromy are natural bedrock chutes/falls. Exceptions are on Bates Creek, which has a dam, and in occasional years when adults get over two bedrock chutes they reach the Laurel Mill Dam on the upper West Branch.
Water Temperature	Water temperature goals for steelhead were not met in the lower mainstem below the Love Creek/Moores Gulch confluence, in the lagoon and in the East Branch between Hinckley Creek and the Water District Weir. Water temperature goals for coho salmon were not met anywhere in suitable habitat in the watershed in 2001, although they were most closely approached in the West Branch and the East Branch above Amaya Creek.
Other	All tributaries had high embeddedness and poor spawning habitat quality due to

	sedimentation. Tributaries provided valuable cooling water to the warmer mainstem and Each Branch and were likely cool enough for coho salmon.

RIPARIAN VEGETATION	
Dominant Vegetation Type	Deciduous tree density decreases slightly moving upstream while evergreen density tends to increase. Alders and cottonwoods abound in the mainstem. The major tree species are represented by a full array of size classes. Small trees are numerous and recruitment is active. The tallest deciduous riparian trees, the Sycamores and Cottonwoods, are generally located on terraces well above the bed of the creek where they became established following heavy flow events.
Canopy Cover	20.6% of sites surveyed achieved the 85% canopy closure recommended by CDFG for coho. Canopy cover tends to increase upstream, with the most cover occurring in the West Branch and the tributaries. There is uneven canopy cover in the mainstem and East Branch.
Non-Native Presence	Non-native species are present throughout, but are most significant in the developed areas. Periwinkle, Ivy, and French Broom are the species that have most actively displaced native vegetation. Pampas Grass is present in the riparian corridor in isolated sites.
Other	Overall, the riparian vegetation in Soquel Creek is in a moderately healthy condition. However, there are numerous locations where existing vegetation is inadequate to contribute to the healthy salmonid habitat. At locations where natural processes remove riparian vegetation, natural regeneration tends to replace the riparian vegetation. Where riparian vegetation is removed by streamside residents, it usually is not allowed to regenerate.

LOWER MAINSTEM (NOB HILL TO MOORES GULCH) – RU6 FINDINGS AND LIMITING FACTORS	
HYDROLOGY & GEOMORPHOLOGY	
Streamflow	Both a gaining and a losing reach. Lower section from the USGS gage to the Walnut Street footbridge could be a chronically losing reach (not natural). High number of diversions. Hydrologic connectivity.
Lateral Channel Adjustment	Propensity to adjust laterally at major meander bends along this reach.
Vertical Bed Adjustment	Both aggrading and degrading – spatially variable. Recorded long-term degradation at the USGS gage with short periods of aggradation in response to such events as the Loma Prieta earthquake.
Sediment Sources	Flood plain terraces store and release sediment and represent chronic sources of predominantly sand sized sediment when active erosion is occurring.
Other	Very high number of shallow and deeper private wells (majority along left bank), several small water systems and one production well
FISHERIES	
Spawning Habitat	Poor to fair due to high sediment content; quality variable depending on location and temporal proximity to large storm events. Locally limited spawning habitat may limit juvenile production.
Rearing Habitat	Generally poor rearing habitat in pools due to a shortage of large woody material and undercut banks, sediment that fills pools and high embeddedness. Poor rearing habitat in fast water riffles and runs due to shallowness and sedimentation leading to high embeddedness.
Pool Habitat	Escape cover in pools has increased since the El Niño stormflows of 1997-98 due to increased overhanging riparian vegetation.
Large Woody Material	Lacking instream; recruitment limited. Shortage limits juvenile production. Movement into mainstem restricted by culverts on Bates Creek and Moores Gulch.
Refuge Potential	Low.
Passage Impediments	Critically wide riffles impede passage, especially formed after high storm events.
Passage Barriers / Extent of Anadromy	None except for the Bates Creek Dam.
Water Temperature	Too high for coho, limiting to steelhead rearing.
Other	Potential for lowering water temperatures with revegetation.
RIPARIAN VEGETATION	
Dominant Vegetation Type	Deciduous with conifers decreasing downstream (natural).
Canopy Cover	Extremely variable, from nearly absent to 85%
Non-Native Presence	High, increasing downstream of Bates Creek.
Other	Cobble bars are naturally revegetating.

The lower mainstem between the lagoon and Moores Gulch provides habitat for low densities of relatively fast growing juvenile steelhead. *The potential for habitat enhancement and increased steelhead production is great here.* The primary limiting factor is high sand content in spawning gravels leading to highly mobile streambed material during storm flows. The result is poor spawning success with poor oxygenation of eggs and high probability of nests being washed away. Juvenile numbers are generally higher between the lagoon and Moores Gulch after mild winters that are followed by low baseflow compared to after wet winters followed by higher baseflow. Spawning conditions are more stable during mild winters, particularly if storms occur primarily early in the wet

season. However, young-of-the-year steelhead grow more rapidly in years with higher baseflow, and a higher proportion reach smolt-size after one growing season.

Soquel Creek between the lagoon and Moores Gulch will likely never be cool enough for rearing coho salmon. However, the well-shaded Bates Creek may support coho salmon in the future, and is likely an important source of young-of-the-year steelhead at present. Two wide meander bends exist between the lagoon and Moores Gulch, as well as two wide cobble bars upstream of Bates Creek, which have been re-vegetating since high storm flows in three successive water years, 1996-1998. Spawning substrate, water depth, escape cover and stream shading have improved since the El Niño winter of 1997-98.

UPPER STEM (MOORES GULCH TO EAST/WEST BRANCH CONFLUENCE – RU5 FINDINGS AND LIMITING FACTORS	
HYDROLOGY & GEOMORPHOLOGY	
Streamflow	This reach appears to be a gaining reach, based on limited spatial data. Hydrologic connectivity between shallow alluvium and underlying bedrock, in the absence of a confining layer.
Lateral Channel Adjustment	High potential for future channel adjustment laterally. Point bars have been moving since 1956.
Vertical Bed Adjustment	Some aggrading but spatially variable.
Sediment Sources	Terraces are eroding. Small bank failures. High sediment storage. Armoring predictable with debris flows.
Other	High number of shallow and deep private wells along the right bank of this reach, a few small water systems
FISHERIES	
Spawning Habitat	Poor to fair due to high sediment content; quality variable depending on location and temporal proximity to large storm events. Locally limited spawning habitat may limit juvenile production.
Rearing Habitat	Generally poor rearing habitat in pools due to a shortage of large woody material and undercut banks, excessive sediment that fills pools and high embeddedness. Poor rearing habitat in fastwater riffles and runs due to shallowness and sedimentation leading to high embeddedness.
Pool Habitat	Good depth due to bedrock outcropping. Shortage of cover due to lack of wood. Escape cover in pools has increased since the El Niño stormflows of 1997-98 due to increased overhanging riparian vegetation.
Large Woody Material	Lacking instream; recruitment limited. Shortage limits juvenile production.
Refuge Potential	Fair. Likely to have hydraulic continuity during drought.
Passage Impediments	None in mainstem. Bedrock chutes and numerous culverts on Moores Gulch.
Passage Barriers / Extent of Anadromy	No barriers present in mainstem. Bedrock chutes and numerous culverts on Moores Gulch are likely barriers during drought.
Water Temperature	Adequate for steelhead; too warm for coho.
Other	High potential to increase shading and reduce water temperatures by planting redwoods at edge of active channel on southern side. Restoration of coho habitat possible with riparian enhancement
RIPARIAN VEGETATION	
Dominant Vegetation Type	Deciduous/evergreen mix, few conifers.
Canopy Cover	Pretty high, though variable: 30-90%
Non-Native Presence	Fairly low.
Other	

The adjacent coniferous forest increases upstream of Moores Gulch, and the stream meanders through more canyon-like terrain with high vertical bluffs. Increased stream shading allows steelhead to occupy slower habitat than downstream. Escape cover improves with more overhanging vegetation. This is a potential coho restoration reach if summer water temperatures are reduced and channel wood increases. Water diversions are minimal in this reach, and residences are usually further from the creek than in lower reaches, though human impact to the riparian corridor is evident in localized stretches.

LOWER WEST BRANCH (MAIN STEM CONFLUENCE TO GIRL SCOUTS FALLS I) – RU4 FINDINGS AND LIMITING FACTORS	
HYDROLOGY & GEOMORPHOLOGY	
Streamflow	The West Branch and tributaries contribute roughly 30 percent of the mean daily streamflow recorded at the USGS gage. Hester Creek is an important perennial tributary. No diversions observed.
Lateral Channel Adjustment	Very little to no channel adjustment is apparent in aerial photographs covering the past 54 years. This is largely due to the interplay between geologic structure and valley and channel evolution-the West Branch flows through a steep sided, narrow gorge.
Vertical Bed Adjustment	Potential to adjust vertically but no direct records were available for analysis, it is highly likely that channel bed vertical adjustment is spatially variable with aggradation and degradation both occurring along this reach.
Sediment Sources	Hester Creek is a large source of sediment, primarily through mass movements on the valley walls and the channel banks, that appears to transport sediment quickly downstream to lower reaches. Laurel and Burns Creeks are also historically large sediment producing tributaries.
Other	
FISHERIES	
Spawning Habitat	Poor to fair due to high amount of fine sediment in spawning gravel (based on visual observation and assumed similar quality to spawning gravel analyzed in the mainstem and lower East Branch), but likely not limiting to juvenile steelhead production.
Rearing Habitat	Poor based on low density of smolt-sized juvenile steelhead produced.
Pool Habitat	Reach dominated by long, unproductive bedrock scoured pools with little cover other than water depth due to the shortage of wood in the channel.
Large Woody Material	Lacking – Wood recruitment hindered and reduced by box culvert at the mouth of Hester Creek and concrete ford above Hester Creek.
Refuge Potential	High.
Passage Impediments	One converted ford between Hester Creek confluence and Girl Scout Falls
Passage Barriers / Extent of Anadromy	None on West Branch to Girl Scout Falls I.
Water Temperature	Good for steelhead, approaching coho tolerance. More shaded below Hester Creek with lower water temperatures.
Other	
RIPARIAN VEGETATION	
Dominant Vegetation Type	Evergreens, especially redwoods.
Canopy Cover	Overall high. Canopy cover is adequate at over half of the locations surveyed
Non-Native Presence	Low.
Other	Wood is delivered episodically.

The lower West Branch, downstream of Hester Creek, has relatively cool summer water that will satisfy coho requirements in some years. However, further stream cooling and more wood must accumulate in this reach to sustain coho salmon. Presently, juvenile steelhead densities are typically low and growth rate is slow due to low summer baseflow and highly sedimented conditions. Hester Creek is a major source of sediment.

UPPER WEST BRANCH (GIRL SCOUTS FALLS I TO LAUREL MILL DAM) – RU4 FINDINGS AND LIMITING FACTORS	
HYDROLOGY & GEOMORPHOLOGY	
Streamflow	Likely gaining. Diversions present.
Lateral Channel Adjustment	Very minor lateral channel adjustment over past 54 years.
Vertical Bed Adjustment	Stable - steep canyon, spatially variable aggradation and degradation depending on disturbance location.
Sediment Sources	Ancient landslides (Laurel and Burns), spatially variable. Large landslides above "Tilley's ford" on West Branch.
Other	
FISHERIES	
Spawning Habitat	Poor to fair, but likely not limiting to production of mostly resident rainbow trout. High young-of-the-year densities indicated good spawning success in mild winters.
Rearing Habitat	Habitat quality upstream of on the West Branch Girl Scout Falls I and II was fair. Reach dominated by moderately productive bedrock scoured pools with little cover other than water depth due to the shortage of wood in the channel. Some pools were quite deep.
Pool Habitat	Good development due to bedrock outcrops; limited escape cover
Large Woody Material	Scarce. Shortage limits juvenile production.
Refuge Potential	High if passage impediments are modified and water diversions in the upper resource unit do not dewater the reach during drought. Lack of large wood or escape cover in pools. Great potential to increase refuge due to low development potential due to steep topography.
Passage Impediments	Both natural and man-made. Two fords.
Passage Barriers / Extent of Anadromy	Large dam and steep boulder barriers (see Appendix A).
Water Temperature	Good for steelhead; may be too high for coho.
Other	Low summer baseflow restricts most rearing of smolt-sized juveniles to pools due to shallowness of fast water habitats. Low summer baseflow results in slow juvenile growth rate.
RIPARIAN VEGETATION	
Dominant Vegetation Type	Primarily Redwood and Douglas-fir with little deciduous representation.
Canopy Cover	75% average canopy cover – may be adequate for steelhead, low for coho.
Non-Native Presence	Low.
Other	

The upper West Branch, beyond the confluence with Hester Creek, has the highest enhancement potential for coho salmon and steelhead by improving spawning access. Modification of two low-water road crossings and two bedrock chutes will improve passage to more than 4 miles of relatively high quality rearing habitat (upstream of the Olsen Road Bridge). Much of the West Branch is now relatively inaccessible. Despite limited access, salmonid densities were relatively high in 2002 above the bedrock chutes, underscoring the potential value of this area. More temperature monitoring is necessary to fully evaluate the potential for coho rearing. Stream sedimentation is high in the upper West Branch from landslides in an unstable zone along the West Branch above Tilly's Ford and in upper tributaries (Laurel and Burns creeks).

LOWER EAST BRANCH (WEST BRANCH CONFLUENCE TO WATER DISTRICT WEIR) – RU3 FINDINGS AND LIMITING FACTORS	
HYDROLOGY & GEOMORPHOLOGY	
Streamflow	Likely a natural gaining reach. Private diversions present.
Lateral Channel Adjustment	Lateral channel adjustment has occurred in the reach between Hinckley Creek and West Branch confluence over the past 54 years. Adjustment occurred at points of meander along this reach.
Vertical Bed Adjustment	Evidence of aggradation present but probably not significant enough to affect fish habitat.
Sediment Sources	Natural slide at Zayante Fault crossing inhibits the deposition of sediment.
Other	Major transition between the upper groundwater basin to the lower basin.
FISHERIES	
Spawning Habitat	Poor rearing habitat; pool habitat was fair with moderate escape cover, though large wood is nearly absent. Pool depth is restricted by sedimentation. Hinckley Creek is good source of young of the year production.
Rearing Habitat	Poor due to sediment – limiting rearing habitat due to embeddedness.
Pool Habitat	The proportion of pool habitat is limited in the segment between Hinckley Creek confluence and the weir due to a shortage of large wood and to the rip-rap that straightened and narrowed the channel. Fast water in riffles and runs is too shallow to for use by smolt-sized fish, which are restricted to primarily pools.
Large Woody Material	Lacking instream. Shortage limits juvenile production.
Refuge Potential	Low due to low streamflow.
Passage Impediments	None on the East Branch.
Passage Barriers / Extent of Anadromy	No barriers present.
Water Temperature	Warm water temperature is limiting to steelhead and prohibitive to coho salmon above Hinckley Creek. Below Hinckley Creek, it limits coho but is adequate for steelhead. Hinkley Creek provides valuable cool water to the East Branch.
Other	The relatively high baseflow of Hinckley Creek makes it a valuable source of surface flow.
RIPARIAN VEGETATION	
Dominant Vegetation Type	Even mix of broadleaf evergreens with deciduous and conifers. *(clarify)* Broadleaved evergreen trees, deciduous species, and conifers are present in about equal proportions.
Canopy Cover	Closure sporadic with greater variability than in other units. Overall, canopy cover has increased since the 1956 aerial photos. This is a location of lateral stream migration.
Non-Native Presence	Nearly as weedy as the lower main stem.
Other	Increased vegetation removal below Hinckley Creek.

Juvenile steelhead density generally increases above Moores Gulch and into the East Branch to Hinckley Creek, as the adjacent coniferous forest increases and the stream meanders through more canyon-like terrain with high vertical bluffs. Escape cover improves with more overhanging vegetation. This resource unit may provide potential coho habitat if summer water temperatures are reduced and instream wood increases. Hinckley Creek provides valuable cold water with relatively high summer streamflow. It augments East Branch streamflow to offset water lost by diversion in the vicinity. The

East Branch between the Hinckley Creek confluence and the Soquel Creek Water District weir is chronically unshaded.

MIDDLE EAST BRANCH (WATER DISTRICT WEIR TO ASHBURY FALLS) – RU2 FINDINGS AND LIMITING FACTORS	
HYDROLOGY & GEOMORPHOLOGY	
Streamflow	Likely a natural gaining reach. No diversions present.
Lateral Channel Adjustment	Moderate amounts of lateral channel adjustment have occurred over the past 54 years in the reach between the Quarry and Amaya Creek. Adjustment occurred at points of meander. From Amaya Creek to Ashbury Falls less adjustment occurred, however significant damage was sustained to the riparian corridor due to the December 1955 flood.
Vertical Bed Adjustment	Dynamic – spatially variable with significant amounts of vertical channel aggradation and degradation possible during storm events equal to greater than bankfull. In WY 1995, SDSF staff observed bed aggradation of 7 to 8 feet in one location during a large storm due to the formation of a log jam
Sediment Sources	Amaya Creek – potential to be a large contributor of wood and large pulses of sediment to system. Amaya Creek is a naturally large sediment producing tributary to the East Branch.
Other	In this unit there is a geologic transitioning from heterogeneous assemblage into the Purisima formation. Changing geologic materials are cut by the Zayante Fault (possibly influencing hydrologic contributions.)
FISHERIES	
Spawning Habitat	Poor to fair due to sediment, although not likely limiting to juvenile steelhead production. This resource unit is the major area for steelhead spawning in the watershed where most of the young-of-the-year juveniles are produced.
Rearing Habitat	Relatively good habitat in pools for smolt-sized fish compared to the remainder of the watershed. Most cover provided under boulders.
Pool Habitat	There is a low proportion of pool habitat in the non-bedrock controlled segment between Amaya Creek and the gradient increase below Fern Gulch, with few pools scoured by large wood or large, perched riparian trees. Pool depth is restricted by sedimentation and lack of good scour objects.
Large Woody Material	Scarce in the East Branch and recruitment is low on the East Branch, but higher in tributaries. Amaya Creek had relatively high amounts of escape cover due to the presence of large wood.
Refuge Potential	High – most productive unit for young steelhead.
Passage Impediments	None to Ashbury Falls.
Passage Barriers / Extent of Anadromy	No barriers present on the East Branch. Large wood cluster on Amaya Creek was a barrier 4,000 feet from the mouth.
Water Temperature	Favorable for steelhead, slightly too warm for coho salmon early in the summer (possibly caused by southern exposure at that time and low summer baseflows).
Other	
RIPARIAN VEGETATION	
Dominant Vegetation Type	Conifers with large deciduous component below Fern Gulch.
Canopy Cover	No data available.
Non-Native Presence	Low.
Other	Shortage of large conifers within 100 year floodplain for both recruitment zone and canopy. Good deciduous contribution to riparian channel

The East Branch between the Soquel Water District weir and Fern Gulch is good coho salmon habitat if more large wood is recruited and cooler summer water temperatures are achieved.

UPPER EAST BRANCH (ABOVE ASHBURY FALLS) – RU1 FINDINGS AND LIMITING FACTORS	
HYDROLOGY & GEOMORPHOLOGY	
Streamflow	Likely a gaining reach. No major diversions present.
Lateral Channel Adjustment	Little potential for lateral adjustment. Will probably respond to large events by adjusting vertically.
Vertical Bed Adjustment	Vertical adjustment is variable.
Sediment Sources	Large landslides present; approximately 22 landslides.
Other	
FISHERIES	
Spawning Habitat	Poor due to fine sediment but not likely limiting to salmonid production. Not many spawning areas in this reach due to abrupt transitions between pools and riffles and the preponderance of sand and cobbles without intermediate gravel sizes.
Rearing Habitat	Habitat quality on the East Branch upstream of Ashbury Falls was relatively good, Most cover provided under boulders. Most pools are bedrock-formed. Stream gradient is too high for coho habitat.
Pool Habitat	Good – most pools are bedrock-formed.
Large Woody Material	In short supply in the East Branch. Not distributed laterally.
Refuge Potential	High if passage impediments are modified.
Passage Impediments	Ashbury Falls. Multiple natural impediments above Falls including bedrock shelves, boulder fields. And impassable log jam. (See Appendix A.)
Passage Barriers / Extent of Anadromy	Extent of anadromy is limited by bedrock waterfall above Highland Bridge
Water Temperature	Good – cool temperatures adequate for coho salmon and steelhead.
Other	
RIPARIAN VEGETATION	
Dominant Vegetation Type	Coniferous with significant (20-40%) deciduous riparian component.
Canopy Cover	85% in surveyed reach in 2002.
Non-Native Presence	Low.
Other	Shortage of large conifers within 100-year floodplain for both recruitment and canopy. Good deciduous contribution to riparian channel.

DATA GAPS

Following are areas where additional information is needed to guide long term enhancement and management of the Soquel watershed.

1. Long-term records of rainfall and flows are essential. Telemetered recording rain gage stations similar in accessibility and information that provided by the Santa Cruz and Watsonville Water Works stations should be operated in the upper and lower portions of the watershed. Long-term baseflow stream gages should be operated on the lower portions of the East and West Forks. In both cases, it may prove feasible to re-occupy or upgrade existing gages. Absence of widely available quality records sustained over decades impedes understanding of low flows and conditions affecting them, a necessary step in protecting and restoring the creek's resources and in meaningfully assessing the creek's instream flow needs.

2. Soquel Creek lacks long-term geomorphic monitoring stations. This represents a significant gap in the geomorphic assessment, as data from this type of monitoring would provide historical data pertaining to channel and riparian conditions likely in different reaches along the mainstem as well as the major tributaries. As a result, discussion of geomorphic change in this report was constrained to analysis of aerial photographs, accounts of conditions in previous literature and results from the long-term gage stability analysis. Long-term channel geomorphic monitoring will help identify (1) long-term processes of channel adjustment (2) reaches which are most heavily impacted by episodic events (3) build an historic database of channel conditions that can be correlated to relevant historic fishery data and (4) answer critical questions which could not be addressed by this assessment due to a lack of data.

3. Much of the bed of Soquel Creek is relatively soft, and likely prone to scour, particularly along the main stem. It is not known whether scour is widespread, or whether it is a significant cause of steelhead egg and fry mortality during egg incubation and fry emergence beyond the area of the 2002 spawning substrate study.

4. The relative contribution of sediment from roads to the channel was not examined or estimated in this assessment. It is likely that fine sediment from roads represents a significant portion of the fine sediment load in years of average to below-average precipitation. During large precipitation years, a large percentage of the fine sediment budget is likely introduced during the re-activation of old landslides or the activation of new landslides. Nonetheless, repair of sediment sources related to roads will likely improve instream conditions during average to below-average rainfall years and periods.

5. Need long-term water temperature monitoring throughout the areas where salmonids can occur.

6. More work is needed to understand the relationship between groundwater pumping and streamflow.

7. A comprehensive analysis of historic and present land use has not been completed for the watershed.

RECOMMENDED PROJECTS

ENHANCEMENT GOALS AND OBJECTIVES

1. To reduce or remove limiting factors affecting juvenile steelhead.
2. To restore coho salmon habitat where feasible.
3. To establish and protect refugia where habitat conditions are particularly suitable for steelhead and/or coho.
4. To provide outreach and educational materials to agencies and landowners regarding best management practices to protect and enhance anadromous salmonid habitat.
5. To promote implementation of projects through technical assistance, education, and financial assistance from available funding sources.
6. To develop and implement projects that will promote the following objectives:
    a. Maximize baseflow and prevent stream reaches from drying out.
    b. Maintain water temperatures throughout the watershed at levels suitable for steelhead
    c. For reaches to be managed for coho habitat, maintain temperatures at cooler levels suitable for coho.
    d. Restore and maintain riparian vegetation for proper floodplain/riparian function and stream cooling.
    e. Minimize fine sediment in spawning gravels and in rearing area.
    f. Restore and maintain adequate levels of large woody material in the channel to provide habitat complexity.
    g. Reduce impediments to adult fish migration, particularly those caused by culverts, dams, and other structures.

REACH-SPECIFIC ENHANCEMENT OPPORTUNITIES

ENHANCEMENT OF THE LAGOON WILL RESULT FROM:

- Constructing the summer sandbar at the Creek mouth sufficiently high to prevent tidal overwash of salt water,
- Maintaining a freshwater lagoon of maximum depth during the dry months of summer and fall,
- Placing large wood in the summer lagoon to create fish cover,
- Reducing pollutants from urban runoff and slowing runoff into the lower creek and lagoon,
- Protecting and enhancing the health of existing trees bordering the lagoon that provide shade,
- Removing and replacing non-native tree and understory species with native riparian vegetation.

ENHANCEMENT BETWEEN THE LAGOON AND MOORES GULCH WILL RESULT FROM:

- Increasing stream shading with planting of trees of large stature (redwood, Douglas-fir and sycamore) near the stream but beyond the danger of removal by high storm flows, particularly in meander bends and adjacent to wide gravel bars,
- Retention of more large wood in the channel for fish cover and pool scouring,
- Enlarging road culverts on tributaries to pass more wood into the mainstem during storm flows,

- Increasing summer baseflow, particularly during drought, through judicious and informed use of surface- and under-flow.

ENHANCEMENT BETWEEN MOORES GULCH (MAINSTEM AND THE CANYON ENTRANCE) TO THE SOQUEL DEMONSTRATION STATE FOREST (LOWER EAST BRANCH) WILL RESULT FROM:

- Protecting the existing riparian corridor to maintain shading,
- Re-planting of conifers and oaks on mostly southern bluffs and along northern flood plains for future wood recruitment and increased shading,
- Retaining more wood in the active channel for fish escape cover and scour,
- Increasing summer baseflow, particularly during drought, through judicious and informed use of surface- and under-flow,
- Cooling of the reach upstream of Hinckley Creek with re-vegetation efforts,
- Restoration of the riparian corridor by reconfiguring the erosion-prevention project upstream of Hinckley Creek.

ENHANCEMENT IN THE EAST BRANCH WITHIN AND UPSTREAM OF THE SOQUEL DEMONSTRATION STATE FOREST WILL RESULT FROM:

- Reducing sedimentation through effective use of Best Management Practices to reduce erosion,
- Reducing sedimentation through effective erosion control and drainage practices on unpaved rural roads,
- Cooling summer water temperatures through planting and retention of redwoods along the riparian corridor,
- Increasing large wood recruitment to the channel for pool scour and fish cover through planting and retention of redwoods along the riparian corridor,
- Improving adult steelhead passage between Ashbury Falls and the Highland Way slide to significantly extend steelhead spawning and rearing into relatively high quality habitat.

ENHANCEMENT IN THE WEST BRANCH WILL RESULT FROM:

- Modifying passage impediments to spawning adult salmonids,
- Increasing summer baseflow, particularly during drought, through judicious and informed use of surface- and under-flow,
- Reducing stream sediment by stabilizing landslide-prone areas and initiating proper erosion control and drainage measures along rural road networks,
- Increasing large wood recruitment from Hester Creek by enlarging the box culvert at its mouth, along with increasing wood retention in the West Branch.

COHO SALMON HABITAT RESTORATION:

The Soquel Creek reaches that should be the focus of coho salmon habitat restoration include 1) the mainstem Fishery Reaches 7-9 (Moores Gulch confluence to Hinckley Creek confluence on the East Branch), 2) Reaches 11 and 12A (Soquel Demonstration State Forest between the Soquel Creek Water District Weir at the lower end of the canyon and the gradient increase below the Fern Gulch confluence) and 3) Reaches 13 and 14a on the West Branch (downstream of the lowermost Girl Scout Falls). If the bedrock chutes at Girl Scout Falls I and II are enhanced for fish passage, coho habitat may be available above.

REACH-SPECIFIC RECOMMENDATIONS

The overarching goal of the Soquel Creek Watershed Assessment and Enhancement Project Plan is to develop and prioritize recommendations for projects and actions that will directly enhance the quantity

and quality of habitat for coho salmon and steelhead. The Recommended Project List includes those specific projects and other actions/programs. The recommendations include removal of passage impediments, conservation and preservation of baseflow, erosion and sediment control measures and projects, revegetation, large wood retention, removal of non-native, invasive species, public outreach and education, monitoring activities, and acquisition of conservation easements and title. Conservation easements and land acquisition in appropriate situations can help protect habitat for coho salmon and steelhead by (1) facilitating preservation of pertinent functional values of riparian forest, (2) potentially reducing stream diversions which otherwise may reduce stream flow and habitat, and (3) potentially reducing sedimentation and runoff by reducing road construction, or reconstruction in erosion-prone areas.

Summary of Recommendations By Watershed Resource Unit

Seven reaches of Soquel Creek were classified into "resource units" (RU) as shown on Figure 3 and summarized in Table 4. Summaries of enhancement efforts envisioned for each unit are provided below in Table 5.

TABLE 5: SUMMARY OF ACTIONS BY WATERSHED RESOURCE UNIT

Resource Unit	Enhancement Benefits	Action Type						
		Sediment & Erosion Control	Fish Passage Improvements	Large Woody Material	Vegetation Planting - Invasive Removal	Conservation Easements	Outreach and Education	Research and Monitoring
RU1	Improve rearing habitat; increase spawning & rearing habitat due to improved passage; provide refuge.	X	X			X		
RU2	Address sedimentation; reduce water temperatures; improve juvenile habitat.	X		X		X		X
RU3	Stabilize channel bends; sedimentation control; reduce water temperatures with increased shading; improve habitat quality.	X			X	X	X	X
RU4	Reduce sedimentation; improve passage; increase and enhance spawning and rearing habitat.	X	X	X		X	X	X
RU5	Overall habitat protection and improvement with enhanced spawning and rearing habitat.		X	X	X	X	X	X
RU6	Enhance spawning and rearing habitat; improve passage; sediment control.	X	X		X	X	X	X

Implementation

Though a number of potential habitat improvement projects were prioritized during the enhancement planning process, the level of detail necessary to fund and implement these projects requires further analysis. There is limited funding available through local, state, and federal grants and agencies, and the funding entities have a limited amount of time to review all prospective projects and make decisions about the feasibility, cost and overall benefit to coho salmon and steelhead habitat enhancement. Private landowners also generally have only limited funding available for participation in enhancement efforts. It is thus important to take the first steps in defining the important elements of the higher-priority

projects. These steps include a description of the project need, initial site assessment, concept-level solutions, preliminary cost estimates, and expected benefit of the project. Additionally, many projects may not necessarily be structural solutions but could be part of a programmatic effort that will provide long-term benefit to coho salmon and steelhead populations. In these cases, it is important to define the initial steps that are necessary to move those programs forward.

OUTREACH AND EDUCATION

Implementations of recommendations contained in this Assessment seek cooperative and voluntary participation of property owners and other agencies and organizations. Similar recommendations have been developed in other Watershed Assessment efforts in Santa Cruz County. Coordination between interested stakeholders should be considered in order to maximize utilization of resources. Strategies for education and public outreach are outlined below.

Recommendations for Education Topics

- Livestock Facility Discharge: manure management, pasture/paddock management, erosion control.
- Agricultural awareness of best management practices to improve water quality.
- Watershed Awareness / Value / Watershed History in order to effectively promote watershed stewardship.
- Water Conservation outreach to households, agriculture and municipalities to promote best management practices to maximize water conservation.
- Summer Base Flow Monitoring for fish and water quality priorities.
- Coordinate with Sierra Club on Grey Water Demonstration Program.
- Research the adjudication and evaluate its history, rights, problems and future scenarios.
- Septic Waste: model after San Lorenzo Inspection Program and encourage Septic Tank Stewardship Program
- Develop a roads outreach program to promote best management practices to reduce sedimentation and improve water quality and fisheries.
- Promote Riparian Corridor habitat and function as it relates to watershed health.
- Stream Function: natural stream function, large episodic events.
- Coho Salmon and Steelhead Trout: unique resource, historical ranges, realistic expectations for recovery, recreational fishing regulations.

Recommendations Outreach Strategies

- Workshops and Tours to promote and provide technical assistance and watershed stewardship opportunities.
- Handouts/ Brochures to provide information on topics pertinent to watershed enhancement.
- Direct Technical assistance to stakeholders regarding erosion, drainage, water quality, water conservation, riparian function, fisheries and roads.
- Video/ PSA (30min/ 3min) in order to develop effective outreach regarding enhancement opportunities for Soquel Creek.
- School Creek Adoption (example: Cotati High School in Sonoma County). Work with local schools and university to promote and maximize education resources: connect with university, liaison with property owners, creek clean-ups, science projects.
- Water Conservation Kits (ex. City of Santa Cruz and Santa Clara Valley Kits): low flow

showerheads, hose nozzles, water conservation information.

Recommendations for Stewardship Development

- Build coalitions/ partnerships in order to effectively develop outreach, education and project success.
- Gather watershed information/ history.
- Point of Contact for information about watershed to exchange information and identify opportunities to participate.
- Promote Watershed via media & public relations in order to promote participation and effective stewardship.
- Participate in regional & statewide watershed efforts to communicate regarding watershed specific priorities.
- Coordinate grant writing in order to maximize resource participation.
- Administer grants.
- Coordinate education & outreach programs.
- Coordinate project implementation.
- Coordinate monitoring, data management & reporting.
- Provide progress updates to agencies, funders & other interested parties.
- Volunteer Coordinator.
- Long-term Funding Strategies: voter approved special assessment district, grant writing and legislation.
- Water Master in order to work with stakeholders on effective water conservation.

MONITORING PROGRAM

The primary objective of a monitoring program is to assess physical and biological changes in watershed conditions over time following implementation of enhancement actions. It is meant to monitor the success or failure of enhancement actions and provide the necessary data to adjust, or adaptively manage, the implemented enhancement program. A monitoring program will be developed; specific monitoring recommendations for the Soquel Creek watershed include:

1. Continue to monitor water temperature on an annual basis at the stations listed in Table 1 of the Fisheries Assessment in order to assess success of management activities.

2. Install additional automated streamflow monitoring stations for the low flow months of May through September to better understand the gain and loss of streamflow. Locations for monitoring in the mainstem and East Branch would be worked out during the implementation phase.

3. Continue to annually monitor juvenile steelhead populations to better understand how the population is influenced by baseflow, winter storm flow patterns and rearing habitat quality. The previous 6 consecutive years of monitoring did not include a drought period. The effects of drought on the juvenile population and/or the recovery time of the population after a drought are not known.

4. Monitor large woody debris density and recruitment potential. The effectiveness of

recommendations to increase the size and allow accumulation of woody debris in and available to the channel to create habitat and provide sediment storage capacity should be monitored. Monitoring should occur regularly, especially after wet years, using inventory protocols that record location, type and size of wood and recruitment potential for channel wood.

RECOMMENDED PROJECT LIST

Recommended projects were compiled by a working group consisting of the consultants and project steering committee, based on information contained in the technical appendices. Priorities were assigned by this working group based on the degree of expected immediate benefit for habitat enhancement and feasibility of implementation as influenced by cost, public acceptance and technical feasibility. Higher effectiveness and higher feasibility resulting in a higher priority (Priority 1 is the highest priority). * indicates immediate and substantial positive benefit to ecosystem or addresses a particularly critical issue.

RU1 – East Branch – Headwaters downstream to Ashbury Falls.

1. **RU1: Conservation Easement/Land Acquisition. Priority 2.** Investigate feasibility of conservation easements and land acquisitions. Conservation easements and land acquisition in appropriate situations may help protect habitat for coho salmon and steelhead by (1) facilitating preservation of pertinent functional values of riparian forest, (2) potentially reducing stream diversions which otherwise may reduce stream flow and habitat, and (3) potentially reducing sedimentation and runoff by reducing road construction, or reconstruction in erosion-prone areas. This area has great potential to provide habitat for juvenile coho salmon and steelhead during times of severe drought, because base flow here increases due to ground-water discharge to the channel and because topography tends to reduce the rate of water-intensive development.

2. **RU1: Address Perched Culvert at Highland Way Slide. Priority 1.** Address perched culvert at Highland Way Slide, which serves to drain the upper, active portion of the Highland Way Landslide. The perched culvert is located on the east side of the landslide and below the road. Currently the culvert is perched by roughly four feet and is contributing to gullying and rilling of the landslide debris below the culvert. During large storms, discharge from the culvert could lead to significant amounts of erosion of the landslide debris and possibly lead to activation of the landslide debris. A simple fix would be to run the drainage further down the slope as close to the stream as possible through the addition of corrugated drainage pipe to the end of the culvert.

3. **RU1: Improve Fish Passage at Ashbury Falls. Priority 1*.** Improve fish passage, located at the beginning of the reach. It is a complex of impediments that partially impede adult steelhead passage unless stormflow raises the water level approximately 2-3 feet. Large boulders jam a narrow canyon to create 4 impediments (#6). A bedrock shelf (#7) is probably the greatest impediment. This complex is known as Ashbury Falls by some and is downstream of Ashbury Gulch. The location is an accumulation point for wood in the channel, adding to passage problems in some years. Improving passage here will give steelhead adults spawning access to relatively high quality rearing habitat.

4. **RU1: Improve Fish Passage at Boulder Clusters. Priority 1*.** This is a series of 4 passage impediments (#8-11) to be modified, all of which are drops created by boulder clusters. The furthest upstream one is the largest. Improving passage here will give steelhead adults spawning access to relatively high quality rearing habitat. All four impediments must be modified to provide good access to at least a mile of high-quality habitat downstream of the Soquel Demonstration Forest Bridge. More habitat is available upstream of the bridge.

RU2 – East Branch –Ashbury Falls downstream to Soquel Creek Water District Weir.

5. **RU2: Conservation Easement/Land Acquisition. Priority 2.** Investigate feasibility of acquisition of conservation easements. Conservation easements and land acquisition in

appropriate situations can help protect habitat for coho salmon and steelhead by (1) facilitating preservation of pertinent functional values of riparian forest, (2) potentially reducing stream diversions which otherwise may reduce stream flow and habitat, and (3) potentially reducing sedimentation and runoff by reducing road construction, or reconstruction in erosion-prone areas. This area has great potential to provide habitat for juvenile coho salmon and steelhead during times of severe drought, because base flow here increases due to ground-water discharge to the channel and because topography tends to reduce the rate of water-intensive development.

6. **RU2: Plant Conifers to Augment / Promote Large Woody Material Recruitment. Priority 2.** This will be achieved by planting redwoods and Douglas-firs in the riparian zone and in upslope and ridge areas. The project is to increase stream shading with planting of conifers, which will also serve as sources of recruitment of large wood to the channel in the future. The reach from the Amaya Creek confluence to the gradient increase below Fern Gulch is low gradient enough for coho salmon, but is somewhat too warm in the early summer and has a shortage of pool habitat that coho juveniles require. There is also a lack of large woody material to scour more pools and provide habitat complexity and cover in pools for steelhead and coho. The entire resource unit has little large wood in the channel to provide escape cover for juvenile salmonids.

7. **RU2: Assess Landslide Stabilization and Sediment Source Reduction in Amaya Creek Watershed. Priority 2.** The project is to assess the feasibility of reducing sediment input from landslides in Amaya Creek, including 'toe' of slope stabilization by protecting the toe of existing landslides and improving runoff drainage over them. Reduction in sedimentation will improve salmonid spawning and rearing habitat, both of which are limited by sedimentation. Conduct a small, field-based landslide inventory project in the Amaya Creek basin coupled with one to two years of winter-time sediment discharge monitoring. Results from this project would be an inventory of chromic sources of sediment and estimates of long-term sediment contribution from these sources and larger features observed in the field. Aging of mapped features would be calibrated through historic aerial photographs and previous landslide mapping in the tributary. A rough sediment budget for the tributary could also be constructed. Along Amaya Creek, evaluate the feasibility of landslide toe stabilization through implementation of remote, field-oriented erosion control projects and possible re-vegetation activities. Numerous landslides and bank failures are present along Amaya Creek. Landslides to be evaluated are small to moderate in size (less than 4,000 to 6,000 square feet) and represent chronic sources of sediment to lower reaches due to destabilization and active erosion at the toes of the landslides.

RU3 – Lower East Branch –Soquel Creek Water District Weir downstream to E/W Confluence.

8. **RU3: Conservation Easement/Land Acquisition for Floodplain and Riparian Corridor Protection. Priority 2.** Evaluate the feasibility of acquiring floodplain properties for the reestablishment of riparian vegetation at meander bends through establishing conservation easements and land and acquisitions. Conservation easements and land acquisition here could help protect habitat for coho salmon and steelhead by facilitating preservation of pertinent functional values of riparian forest and floodplain. Substantial lateral movement of the channel is predictable here. The frequency and magnitude of lateral movement is partly related to the riparian forest in the floodplain and at meanders. When floodplain and riparian forest function properly, lateral movement may be slower, reducing adverse effects on stream habitat. When floodplain has been reduced and riparian forest thinned substantially, adverse affects of lateral movement on stream habitat are more pronounced. Structural constraints on lateral migration

(e.g., via protecting the banks from erosion) is likely futile in the intermediate- to long-term and even the best such projects have substantial short-term adverse affects on stream habitat. The durable response to lateral movement of the channel here is to implement conservation easements that preserve functional values of riparian forest in floodplains and at meanders.

9. **RU3: Upgrade Flow Gage and Make Information Available on Internet. Priority 1.** Make stream flow data collected for the Soquel Creek Water District gage at the weir available to the public over the internet (telemetered gage). Spring and summer baseflow are limiting to salmonid rearing habitat. Growth rates of juvenile steelhead increase with more baseflow, leading to a greater proportion of young-of-the-year fish reaching smolt size and entering the ocean. This will have a positive impact on return of adult steelhead. The project to install dry-season, continuous streamflow gages will have a number of benefits. It will help to better understand the gaining and losing nature of the stream. It will serve to educate water diverters of the effects of water diversion on surface flow. The data will be the basis for cooperation between water diverters in coordinating their diversions to minimize baseflow reduction. It will measure the effectiveness of the restoration efforts to obtain cooperation from water diverters to maximize baseflow for salmonid rearing habitat.

10. **RU3: Reconfigure and Revegetate Existing Rip-rap. Priority 1.** Reconfigure rip-rap where there is absence of riparian habitat, increased water temperature, and associated erosion. Re-construction of extant rock rip-rap will reduce erosion of adjacent channel and improve functional values of riparian forest. Prior efforts to reduce bank erosion by placement of rock rip-rap have reduced floodplain and riparian forest along greater than 1,800 linear feet of channel. Re-construction of the rip-rap to current Best Management Practices will reduce erosion of adjacent channel and improve functional values of riparian forest by adding area to the floodplain and riparian forest.

11. **RU3: Revegetation at Locations with Limited Shading. Priority 1.** Investigate feasibility of planting trees to reduce solar radiation (at Transects 35, 37-41, 47-51) to increase density & stature of trees above bankfull where they may offer increased stream shading where physical conditions and landowner participation are favorable, develop planting plan and implement planting. The vegetation assessment identified several locations where solar radiation is particularly intense and where tall trees planted above the bankfull level could provide shading to reduce water temperatures. A site visit should be made to determine whether the physical conditions (proximity to surface water, soil texture) at Transects 35, 37-41, 45, and/or 46a-51 are suitable for planting tall trees. The landowners should be contacted by RCD to assess their interest and their potential to support a planting by deeply irrigating new trees for the first three summers after planting. Where the physical conditions and landowner participation are favorable, develop a planting plan and implement the planting.

12. **RU3: Assessment of Riparian Vegetation Die-off. Priority 5.** Identify date and cause of changed hydrology that is/was fatal to riparian trees on west bank (at Transect 50) to address lack of knowledge about hydrological requirements of riparian trees at this site. At Transect 50, most of the trees on the west bank terrace are dead or dying. According to the owner of the adjacent quarry, the stream changed course and downcut during one rainy season. Research into factors behind the tree decline (soil texture, amount of drop in the water table, fault activity) could help to gain an understanding of the limits of riparian tree response to changed conditions.

13. **RU3: Tree Planting Above Bankfull at Transect 58. Priority 4.** Investigate feasibility of planting trees to reduce solar radiation on Hinckley Creek (at Transect 58). If physical conditions and landowner participation are favorable, develop planting plan and implement planting. At

Transect 58 on Hinckley Creek, solar radiation is high and tall trees planted above the bankfull level could provide shading to reduce the water temperatures. A site visit should be made to determine whether the physical conditions (proximity to surface water, soil texture) are suitable for planting tall trees. The landowners should be contacted by RCD to assess their interest and their potential to support a planting by deeply irrigating new trees for the first three summers after planting. Where the physical conditions and landowner participation are favorable, develop a planting plan and implement the planting.

14. **RU3: Conservation Easements. Priority 2.** Conservation easements and land acquisition here could help protect habitat for coho salmon and steelhead by (1) facilitating preservation of pertinent functional values of riparian forest, (2) potentially reducing stream diversions which otherwise may reduce stream flow and habitat, and (3) potentially reducing sedimentation and runoff by reducing road construction, or reconstruction in erosion-prone areas.

15. **RU3: O&E Program – Retention of Large Conifers and Wood Clusters in Floodplains. Priority 2.** Improve riparian habitat value and protect against erosion on Hinckley Creek and promote retention of wood clusters for instream sediment capture and habitat values through educational efforts. This project is an educational effort directed to landowners who carry out timber harvests in riparian corridors in the Hinckley Creek sub-watershed. The purpose is to impress upon them the importance of leaving undisturbed, a portion of the large conifers in close proximity to stream channels and all other streamside vegetation. The benefits of a properly functioning riparian corridor are protection of cool water temperature through shading, streambank protection from erosion and future recruitment of large wood that provides habitat complexity and increased fishery habitat. This project is also an educational effort directed at landowners and the County flood control department to retain wood clusters in the stream channel. Benefits include increased habitat complexity, increased scour of pools, greater water depth and more escape cover and rearing habitat for juvenile salmonids. Wood in Hinckley Creek will serve as wood to be recruited into the East Branch.

16. **RU3: O&E Program – Feasibility of Alternatives for Hinckley Creek Wet-Crossings. Priority 5.** Encourage stakeholders to evaluate their needs to cross Soquel Creek at the confluence of Hinckley Creek and implement a transportation plan that does not include the extant "wet-crossing" of Soquel Creek. Soquel Creek at the confluence of Hinckley Creek is crossed by vehicle traffic without benefit of a bridge or other year-round crossing. This type of crossing is hazardous to people, chronically damages instream habitat of coho salmon and steelhead, and poses a risk of oil and fuel spills into Soquel Creek.

17. **RU3: Erosion Assessment and Mitigation for Hinckley Creek Road. Priority 2.** Identify all significant sources of ongoing or future erosion attributable to Hinckley Creek Road, describe the magnitude of risk at each site, and prioritize treatment based on an interaction of risk to stream habitat and cost. Roads are common in the watershed and erosion attributable to most of these roads causes sedimentation of stream habitat. When implemented, Best Management Practices (treatments) for road re-construction and maintenance reduce erosion attributable to roads, lower the costs to maintain roads, and improve "driveability" of roads ---- while protecting stream habitat.

RU4 – West Branch – Headwater downstream to E/W Confluence.

18. **RU4: Conservation Easements. Priority 3.** Conservation easements and land acquisition here could help protect habitat for coho salmon and steelhead by (1) facilitating preservation of pertinent functional values of riparian forest, (2) potentially reducing stream diversions which

otherwise may reduce stream flow and habitat, and (3) potentially reducing sedimentation and runoff by reducing road construction, or reconstruction in erosion-prone areas.

19. **RU4: Erosion Assessment and Mitigation for Roads. Priority 2.** Identify all significant sources of ongoing or future erosion attributable to roads in the lower West Branch Soquel and the upper West Branch Soquel watershed, describe the magnitude of risk at each site, and prioritize treatment based on an interaction of risk to stream habitat and cost. Roads are common in the watershed and erosion attributable to most of these roads causes sedimentation of stream habitat. When implemented, Best Management Practices (treatments) for road re-construction and maintenance reduce erosion attributable to roads, lower the costs to maintain roads, and improve "driveability" of roads ---- while protecting stream habitat.

20. **RU4: Reestablish Flow Gaging Station. Priority 2.** Re-establish discharge gaging station on West Branch, located below Hester Creek confluence and make data available to public on web (telemetered project).

21. **RU4: Encourage Reduction of Stream Diversions. Priority 1.** Encourage stakeholders in the lower West Branch Soquel watershed to evaluate their need to divert streamflow, develop a plan to preserve streamflow during periods when diversion of streamflow would substantially reduce the amount of habitat, and to implement that streamflow preservation plan. This area has great potential to provide good habitat for juvenile coho salmon and steelhead during times of severe drought and geologic instability, because base flow here increases due to ground-water discharge to the channel, water temperature is relatively cool due to topographic shading, and substrate relatively high quality because the geology is relatively stable.

22. **RU4: Assess feasibility of Landslide Stabilization and Erosion Control. Priority 5.** Evaluate feasibility of minimizing impacts from landslides on salmonid habitat through implementing erosion control projects and possibly revegetating these areas on landslide "toe" between 2nd ford and 1st Laurel mill dam. [Erosion sites #22-28 in Table 9 of Fisheries Appendix] Landslide stabilization feasibility project. In the reach between the 2nd ford and the 1st Laurel Mill Dam, evaluate the feasibility of landslide toe stabilization through implementation of remote, field-oriented erosion control projects and possible re-vegetation activities. Landslides to be evaluated are small to moderate in size (~<10,000 square feet) and represent chronic sources of sediment to lower reaches due to destabilization and active erosion at the toes of the landslides.

23. **RU4: Modify Culvert and Old Dams for Fish Passage Improvement. Priority 2.** Develop and implement improvements to migration of coho salmon and steelhead past structures at Laurel Mill Lodge (a ~15 tall concrete dam), Redwood Lodge Road (a ~100ft-long CMP), and approximately 0.5 miles upstream of the West Branch Soquel-Laurel Creek confluence (a ~15 tall concrete dam). Approximately 2 miles of coho salmon and (predominantly) steelhead habitat would become available if fish passage is provided at the first two sites. Approximately 0.8 miles of (predominantly) steelhead habitat would become available if fish passage is provided at the last site.

24. **RU4: Replace Concrete Ford Upstream of Hester Creek for Fish Passage Improvement. Priority 1*.** Replace the culverted concrete ford upstream of the Hester Creek confluence on the West Branch with a free-span bridge.

25. **RU4: Fish Passage Improvement at Tilly's Ford. Priority 1*.** Improve fish passage at the unculverted ford 10,000 feet above Olsen Road [Impediment # 17 (Tilly's ford) in Table 12 of Fisheries Appendix]. Once this ford has been laddered or otherwise improved for adult steelhead

passage, then the one man-made barrier between it (10,000 feet above Olsen Road; 17,150 ft above Hester Creek confluence) and the Laurel Mill Dam (23,250 feet above Olsen Road; 30,400 ft above the Hester Creek confluence) is a small grade-control structure (11,000 feet above Olsen Road; 18,150 ft above the Hester Creek confluence).

26. **RU4: Fish Passage Improvement at Bedrock Chutes and Wood Clusters above Olsen Road. Priority 1*.** The upper West Branch, upstream of Girl Scout Falls I and II had relatively good habitat and relatively high salmonid densities in 2002, comparable to the middle East Branch of Soquel Creek. It is uncertain whether the fish were primarily resident or not at this point. However, this portion of the watershed has great fishery potential and high refuge potential. The project is to modify passage impediments from Girl Scout Falls I, 600 feet upstream of the Olsen Road Bridge (7,750 ft above the Hester Creek confluence) to the unculverted, Tilly's ford, 10,000 feet upstream of Olsen Road (17,150 feet upstream of the Hester Creek confluence). The impediments will be modified from downstream to upstream, beginning with Girl Scout Falls I (#13 in Table 12 of Fisheries Appendix), a 7-foot drop over a wide bedrock chute 15 feet long and 600 feet upstream of Olsen Road (7,750 ft above the Hester Creek confluence). The second is a narrow bedrock chute (#14 in Table 12 of Fisheries Appendix) creating a 5-foot drop, 890 feet upstream of Olsen Road. The third impediment is a 10-foot high wood cluster (#15 in Table 12 of Fisheries Appendix) that spanned the channel at a constricted 20-foot width and was 30 feet long, 2,600 feet upstream of Olsen Road (9,750 ft above the Hester Creek confluence). The fourth impediment is Girl Scout Falls II (#16 in Table 12 of Fisheries Appendix), a 12-15-foot drop over a wide bedrock chute 25 feet long, 3,660 feet upstream of Olsen Road (10,800 ft above the Hester Creek confluence). The benefit of modifying these 4 passage impediments will improve passage of adult steelhead and coho salmon to 9,400 feet of relatively high quality stream channel (1.8 miles) most of which is inaccessible to adults in most years (at least the 6,340 feet above Girl Scout Falls II).

27. **RU4: Modify Redwood Lodge Road Culvert for Passage of Large Woody Material. Priority 3.** Replace existing culvert crossing with larger culvert or bridge to improve passage of large woody material into downstream areas of West Branch Soquel Creek. Increased passage of large woody material will benefit salmonids by providing cover and promoting pool scour and spawning areas.

28. **RU4: Landslide Stabilization Feasibility Project, Hester Creek and West Branch. Priority 4.** Assess feasibility of landslide 'toe' slope stabilization throughout the West Branch. Along lower Hester Creek, evaluate the feasibility of landslide toe stabilization through implementation of remote, field-oriented erosion control projects and possible re-vegetation activities. Numerous landslides are present along the lower 4000 feet of Hester Creek. Landslides to be evaluated are small to moderate in size (less than 4,000 to 6,000 square feet) and represent chronic sources of sediment to lower reaches due to destabilization and active erosion at the toes of the landslides.

29. **RU4: O&E Program - Move Large Woody Material from Hester Creek into West Branch. Priority 1.** Retain Wood Clusters for instream sediment capture benefits. Without culvert replacement at the mouth of Hester Creek, the natural transport of wood from Hester Creek into the West Branch will continue to be interrupted. Wood will accumulate on the upstream side of the culvert during large storm events. The West Branch downstream of Hester Creek has a shortage of large woody material in the channel. Therefore, the project is to move wood from the upstream side of the culvert to the downstream side of the culvert by pushing or pulling it through the culvert or otherwise transporting it downstream of the culvert. The wood should be moved into the main channel of the West Branch. This recruitment of wood will increase channel complexity, encourage scour, increase water depth in scoured areas and increase fish cover and

rearing habitat for juvenile salmonids.

30. **RU4: <u>O&E Program - Community Creek Cleanup</u>. Priority 1.** Establish a number of "Clean-ups" to remove trash, car bodies, etc. dumped from Soquel-San Jose Road, and install "NO DUMPING" signs. Hester Creek contains much trash, including car bodies, dumped from Soquel-San Jose Road. There may be interest in a community clean-up to remove the debris, although access may be challenging because of the steep slopes. Since the County has a program to abate abandoned vehicles, cars are no longer dumped here. If “No Dumping” signs are not present at the roadside, they should be installed.

31. **R4: <u>Culvert Replacement/Improvement, Soquel-San Jose Road at Hester Creek</u>. Priority 2.** Develop and implement an improvement to migration of predominantly steelhead, and movement of large woody material, past the crossing of Hester Creek at Soquel-San Jose Road near the West Branch Soquel-Hester Creek confluence. The current crossing is a box culvert that is “0% passable” (Ross Taylor) and is prone to obstruction by large woody material. Relatively little habitat in Hester Creek would be made frequently available by implementation of a fish passage improvement project here because of geologic and large woody material jams beginning 1800 feet upstream of the site. A project here would (however) be particularly important, because unimpeded movement of large woody material past the site will likely discourage clearing of large woody material in Hester Creek and the additional large woody material will improve stream habitat in lower West Branch Soquel Creek and mainstem Soquel Creek.

RU5 – Upper Main Stem – E/W Confluence downstream to Moores Gulch.

32. **RU5: <u>Conservation Easement/Land Acquisition</u>. Priority 2.** Conservation easements and land acquisition here could help protect habitat for coho salmon and steelhead by (1) facilitating preservation of pertinent functional values of riparian forest, (2) potentially reducing stream diversions which otherwise may reduce stream flow and habitat. This area has great potential to provide habitat for juvenile coho salmon and steelhead during times of severe drought, because base flow here increases due to ground-water discharge to the channel. However, future development here could compromise this refuge because topography allows relatively more water-intensive development and use of floodplain.

33. **RU5: <u>Maintenance and Enhancement of Groundwater Recharge</u>. Priority 1.** Recharge zones should be identified and measures should be implemented to encourage maintenance and enhancement of recharge functions, to enhance storage of groundwater which also supplies summer baseflow to the creek. Protection of primary recharge zones could be pursued via conservation easements or direct property transfer. Protection of recharge could also be facilitated by education and outreach and encouraging drainage practices which promote recharge. Landowner cooperation would be imperative to implementation of this project since a large majority of the land in this reach is held by numerous private citizens or businesses.

34. **RU5: <u>O&E Program – Alternatives to Purling Brook Wet-Crossing</u>. Priority 5.** Encourage stakeholders to evaluate their needs and alternatives for crossing Soquel Creek at Purling Brook and implement a transportation plan that does not include the extant “wet-crossing” of Soquel Creek. Soquel Creek here is crossed by vehicle traffic without benefit of a bridge or other year-round crossing. This type of crossing is hazardous to people, causes chronic localized damage to instream habitat of coho salmon and steelhead, and poses a risk of oil and fuel spills into Soquel Creek.

35. **RU5: Revegetation of Streamside Areas. Priority 2.** Assess feasibility of revegetating streamside areas w/appropriate species to increase stream shading and LWM recruitment; increase tree density & stature within the Riparian Zone to reach >75% canopy (Willow/Creek Dogwood/Alder/Sycamore). The upper mainstem was too warm for coho salmon in 2002, but has the potential for water temperature reduction and restoration of coho rearing habitat. There was an extreme shortage of large wood in the channel.

36. **RU5: Revegetation of Bluffs. Priority 3.** Assess feasibility of revegetating bluffs with appropriate species to increase stream shading and LWM recruitment; increase tree density & stature within the Riparian Zone to reach >75% canopy. Solar radiation along the Upper Main Stem of Soquel Creek is not unusually high, but steep banks and bluffs along this section of the creek provide opportunities to increase the amount of shade on the creek, as well as the recruitment of large woody material, by planting upland species such as Live Oak, Douglas-fir and Big-leaf Maple. Transects 25a, 26, 26a, 28a, 30, 33 and 34 had canopy closure values less than 75% and should be revisited for their potential as planting sites.

37. **RU5: Revegetation of Bank Stabilization Projects. Priority 2.** Revegetate private stream bank stabilization projects downstream of Purling Brook ford, for up to 300 feet. This project is to educate landowners downstream of Purling Brook ford about the benefits of planting riparian vegetation for coho and steelhead habitat restoration now that they have armored their streambank with gabion baskets. With the landowner's cooperation, the project will include revegetation of the armored bank with riparian tree species.

38. **RU5: Evaluate and Improve Fish Passage at Crossings of Moores Gulch. Priority 5.** Analyze fish passage at all crossings of the perennial reach of Moores Gulch. Approximately 10 crossings likely impede migration of steelhead and are prone to obstruction by large woody material. Approximately two miles of relatively poor habitat in Moores Gulch would be made available (or more often available) by implementation of all necessary fish passage improvements here. Installation of bridges or appropriately-sized culverts here would be important from an ecosystem perspective, because unimpeded movement of large woody material past the site will likely discourage clearing of large woody material in Moores Gulch and the additional large woody material will improve stream habitat in lower Soquel Creek.

39. **RU5: Improve Fish Passage Movement of Large Woody Material on Moores Gulch at Soquel-San Jose Road. Priority 3.** Develop and implement an improvement to migration of adult coho salmon and steelhead, and movement of large woody material, past the crossing of Moores Gulch at Soquel-San Jose Road near the Soquel Creek-Moores Gulch confluence. The current crossing is a "0% passable" (reference) culvert with non-standard fish ladder and is prone to obstruction by large woody material. Relatively little habitat in Moores Gulch would be made available by implementation of a fish passage improvement project here because of geologic and anthropogenic impediments beginning a few hundred feet upstream of the site. Installation of a bridge or appropriately-sized culvert here would (however) be important from an ecosystem perspective, because unimpeded movement of large woody material past the site will likely discourage clearing of large woody material in Moores Gulch and the additional large woody material will improve stream habitat in lower Soquel Creek.

RU6 – Lower Mainstem –Moores Gulch downstream to Nob Hill Area.

40. **RU6: Conservation Easements for Streambank and Floodplain. Priority 2.** Acquire conservation easement or purchase property-stream mile 2.4. Through direct purchase or conservation easement, acquire right to property along the left bank (looking downstream) at

stream mile 2.4: dimensions of purchase or easement would be approximately 100 feet in width starting at bank edge and for approximately 1000 feet upstream and downstream of stream mile 2.4. Through the purchase or easement, the land would be left to natural processes with re-vegetation projects accordingly planned for the acreage.

41. **RU6: Water Rights Acquisition through Conservation Easements. Priority 2.** Through direct purchase or through a conservation easement, acquire surface or groundwater rights of roughly 0.5 to 2.0 cubic feet per second from existing permit holders.

42. **RU6: Revegetation of Meander Bend. Priority 1.** Perimeter re-vegetation along the left bank at stream mile 2.4. Plant the appropriate species (i.e. Douglas-fir, Redwood, or Sycamore) along the outer edge (furthest from the stream) of the purchased or leased land along the left bank at stream mile 2.4. The planting should more or less follow the plan-view morphology of the channel and would occur roughly 100 feet from the edge of the left bank (looking downstream). The planting would effectively create a wall of even-aged trees to facilitate the regeneration of a riparian or woodland buffer along the left bank of this reach and would aid in stabilization of the meander bend, future recruitment of large wood, decreased destruction of private property and enhanced ecosystem functionality of this reach.

43. **RU6: Revegetation to Restore Riparian Forest and Reduce Solar Radiation. Priority 2.** Investigate feasibility of planting trees to reduce solar radiation and generate a "Functional Riparian Forest" at Transects 1-5, 9-9a, 11, 21-22a. Where physical conditions and landowner participation are favorable, develop planting plan and implement planting. Projects: 1) Channel bank stabilization downstream from Whiteheads' bend (2.2 mi) Area of Giant Right Bank Cobble bar for. 2) Improve riparian canopy cover in meander bend downstream of Whitehead meander area by planting riparian/ conifer tree species of stature [Riparian Corridor Ord. "help us to help you 'save your property']; 3) Improve riparian canopy cover in meander bend downstream of Moores Gulch near the Mountain School by planting riparian/ conifer tree species of stature; 4) For entire resource unit, provide revegetation of riparian corridor with tree species of tall stature to stabilize stream bank, increase stream shading and provide recruitment of LWM. The vegetation assessment identified several locations where solar radiation is particularly intense and where tall trees planted above the bankfull level could provide shading to reduce the water temperatures. A site visit should be made to determine whether the physical conditions (proximity to surface water, soil texture) at Transects 1-5, 9-9a, 11, and/or 21-22a are suitable for planting tall trees. The landowners should be contacted to assess their interest and their potential to support a planting by deeply irrigating new trees for the first three summers after planting. Where the physical conditions and landowner participation are favorable, develop a planting plan and implement the planting.

44. **RU6: Establish Stakeholder Group to Pursue Increased Baseflow. Priority 1*.** Establish or re-establish a stakeholder process or watershed council who will explore and promote opportunities to assure diversion of streamflow (directly or indirectly) is consistent with perpetuation of Soquel Creek coho salmon and steelhead. Among others, these opportunities include amendments to the adjudication, water conservation, shallow recharge opportunities, shallow-well gauging, deep-well gauging, and self-monitoring of diversions.

45. **RU6: Bank Stabilization and Revegetation at Nob Hill . Priority 2.** Stabilization of right bank at Nob Hill, 200 meters downstream of Highway 1. Attempt to stabilize the retreating bank, perhaps with a combination of crib wall construction, fresh riparian woodland planting behind each crib structure, and placement of large wood at the toe of the wall. Fill material for the crib wall could be harvested from the bar opposite the bank and currently existing large wood at the site could be used to stabilize the bank toe. Final plans would need to be designed by a

licensed engineering geologist with oversight by a Fisheries Biologist with special concern to spawning at the head of the bar upstream from the failing bank.

46. RU6: Shield Creek from Lights under Highway 1. Priority 1. Observations indicate that adult steelhead congregate under the Highway 1 Bridge. Adults migrate primarily at night and may be inhibited from entering the lighted stream channel upstream of the bridge at night due to lighting from Highway 1 and Wharf Road, which also passes under the Highway 1 Bridge. The project is to shield the creek from these light sources in order to facilitate upstream passage of spawning adult steelhead. The fish will be less vulnerable to anglers if they do not congregate under the bridge. Consultation with Cal Trans and the City of Capitola will be required.

47. RU6: Localized Non-Native Vegetation Removal (Arundo). Priority 1. Removal of non-native invasive plant species. Remove Arundo donax (Giant Reed) at the 6 locations where it occurs and, where needed, Revegetation with native Riparian zone species from Moores Gulch to the lagoon. Giant Reed *(Arundo donax*) occurs at six locations, and its early removal would save potentially tens of thousands of dollars that would be entailed in eradication if it is allowed to proliferate. The work could be done by the Community Action Board, the California Conservation Corps (CCC) or the County. Four of the sites are in the creek channel, and two are planted locations on private property.

48. RU6: Extensive Non-Native Vegetation Removal and Native Revegetation. Priority 2. Remove non-native invasive plant species and, where needed, revegetate with native riparian-zone species from Porter Street Bridge over Soquel Creek to Nob Hill. Nob Hill is the beginning of the lagoon for all instances of English & Cape Ivies in the tree canopy, and Jubata Grass. After Giant Reed, the invasive exotic plant species with highest priority for removal are English Ivy where it is in the tree canopy, French Broom, Jubata Grass (=Pampas Grass), and Cape Ivy in the canopy. The urban area downstream of the mouth of Bates Creek, and the portion of Bates Creek downstream from the Main Street crossing, have the heaviest infestation of invasive exotic plants. Demonstration projects to remove the most aggressive non-native plants should be targeted toward these species, and, where needed, the sites should be replanted with native riparian zone species.

49. RU6: Feasibility of Percolation Basin Recharge and Detention. Priority 3. Assess the feasibility of establishing a percolation basin on the east bank adjacent to Highway 1 (Bay St on SW side of street). Polluted stormwater runoff poses health hazards to fish rearing in the lagoon, particularly after the first rain of the wet season. A fish-kill occurred in the past. In addition, in this urbanized portion of the lower watershed, rainfall is lost immediately to runoff because of impermeable surfaces that prevent groundwater percolation and recharge. There is flashy runoff that often prematurely breaches the sandbar at the beach after the first storm of the season, and the first storm of the season is often followed by weeks without rain. The project is to assess the feasibility of constructing a percolation basin for stormwater runoff in the vicinity of Highway 1 to receive the runoff from 41st Avenue, the freeway and some of Capitola.

50. RU6: Stormwater Filtration. Priority 2. Upgrade and manage stormdrain system, incorporate detention basins, and use of a VACTruck in Soquel Village and Capitola. Study the feasibility of installing underground water catchment basins on major storm drains entering lower Soquel Creek from 41st Avenue and Wharf Road to trap sediment and grease. Install them if feasible. Support implementation of other stormwater management measures to reduce pollutant discharge to the creek. This will reduce the artificially sudden increase in streamflow, organic material, and road pollutants into the lagoon during the first storms of the season and improve lagoon water quality. Polluted stormwater runoff poses health hazards to fish in the lagoon, particularly after the first rain of the wet season. A fish-kill occurred in the past.

51. **RU6: Feasibility of Infiltration Galleries. Priority 3.** The project will be to assess the feasibility of installing run-off infiltration galleries for recharge/water percolation in Capitola and Soquel Village, replacing storm drains. If the galleries prove feasible, they will improve water quality by reducing storm runoff pollution. The project will reduce flashiness of runoff, possibly prolonging the integrity of the sandbar until storms become more frequent later in the wet season. Obtain a conservation easement or purchase open space land in the Soquel Village and Capitola area where urban surface runoff may be piped and infiltrated into the groundwater.

52. **RU6: Bates Creek Dam Feasibility Study. Priority 2.** Assess the feasibility and landowner interest in: A) removing the Bates Creek Dam for fish & LWM passage; or B) using Bates Creek Dam as a sediment catch basin. The dam is currently sedimented with numerous active sources of sediment upstream of the dam. A major consideration in this project is the structural integrity of the dam and the potential for future dam failure.

53. **RU6: Landslide Stabilization Feasibility Project, Bates Creek. Priority 5.** Along lower Bates Creek, evaluate the feasibility of landslide toe stabilization through implementation of remote, field-oriented erosion control projects and possible re-vegetation activities. Landslides and bank failures are present along Bates Creek above and below the dam. Landslides to be evaluated are small to moderate in size and represent chronic sources of sediment to lower reaches.

54. **RU6: Replace Culvert Crossing of Main Street over Bates Creek. Priority 2*.** Replace Main Street culvert crossing of Bates Creek with arch culvert or free-span bridge to improve passage for adult and juvenile salmonids and to improve passage of large woody material into lower Soquel Creek. The benefit will be increased fish passage under a variety of flow conditions into good habitat upstream. Increased passage of large woody material will benefit salmonids by providing cover and promoting pool scour and spawning areas.

55. **RU6: Non-Native Vegetation Removal, Lower Bates Creek. Priority 3.** Remove exotic plant species along Bates Creek from Main Street crossing to confluence w/Main stem Soquel Creek.

56. **RU6: Fish Passage Improvement, Lower Bates Creek Bedrock Chute and Falls. Priority 1*.** Remove 2 passage impediments on Bates Creek between the dam and the mainstem Soquel Creek: 1) "Bedrock chute" ~6900' upstream of Soquel Creek and 2) "falls w/redwood stump" near confluence with Grover Gulch. Bates Creek is the only fish-bearing tributary in the lower mainstem capable of seeding the sediment-laden mainstem with young-of-the-year steelhead. It is a potentially valuable spawning and rearing area, though it is also a potentially great sediment source. The project is to modify two passage impediments that will better accommodate adult steelhead passage to the Bates Creek Dam. The lower, wide bedrock chute located 2,600 feet upstream of the Main Street Bridge, probably requires more than bankfull flows of 100+ cfs to be reasonably passable. It was a 7-foot vertical drop over 2 steps and 30 feet long. It was 17 feet wide. The bedrock falls with old-growth redwood stump may require passage flows in excess of bankfull in the 150-200 cfs range. It consisted of an 8-foot drop in a narrowly incised bedrock section that was 3,100 feet upstream of the Main Street Bridge. The 20-30-foot high Bates Creek Dam was impassable to adult steelhead and was located 6,900 feet upstream of Main Street. Therefore, improving the two impediments will improve adult steelhead access to 4,300 feet of habitat (0.8 miles) that may be inaccessible in drier winters.

57. **RU6: O&E Program – Advocacy for Use of BMP's for Stables, Nurseries, Residents. Priority 1.** Develop outreach program targeted at specific uses (e.g. horse owners, nurseries,

residents) to encourage landowners to protect stream habitat through riparian corridor conservation and enhancement, minimizing impacts to water quality and water conservation. Outreach program could include information, resources and technical assistance. Activities may include workshops, direct technical assistance, and dissemination of the County of Santa Cruz Stream Care Guide and coordination of resources with interested landowners.

RU7 – Lagoon – See Soquel Lagoon Management Plan Update, City of Capitola.

RU8 – Watershed Wide – Throughout the Entire Watershed.

58. RU8: Erosion Assessment and Sediment Reduction– Non-County Roads. Priority 1*. A sediment reduction program for private roads should be designed as a cooperative effort between local governments and private landowners, which would include outreach, technical assistance and cost-sharing funding assistance. As a part of this, identify all significant sources of ongoing or future erosion attributable to non-County roads, describe the magnitude of risk at each site, and prioritize treatment based on an interaction of risk to stream habitat and cost. Roads are common in the watershed and erosion attributable to most of these roads causes sedimentation of stream habitat. When implemented, Best Management Practices (treatments) for road re-construction and maintenance reduce erosion attributable to roads, lower the costs to maintain roads, and improve "driveability" of roads ---- while protecting stream habitat.

59. RU8: Instream Flow Modeling. Priority 1. Describe the relationship between streamflow and the amount of instream coho salmon and steelhead trout habitat at three sites using Instream Flow Incremental Methodology, where the selected sites are characteristic of source, transport and storage reaches, and then monitor the amount of instream habitat at those sites using real-time streamflow data posted on the internet. Develop accurate exceedence probability curves to predict late summer flow conditions. Exceedence probability curves should be developed for several locations in the Soquel Watershed (mainstem and branches) based on historic flow data for wet, average, dry, and drought conditions. If predicted flows are below a level considered critical to maintain viable rearing habitat for salmonids, measures to reduce water consumption can be initiated by water users in the Soquel Watershed through conservation programs

60. RU8: Water Temperature Monitoring. Priority 1. Install 'hobo temp' data recorders throughout the watershed. Warm water temperature is a limiting factor to steelhead in the lower mainstem, the lagoon and the East Branch between Hinckley Creek confluence and the Soquel Creek Water District weir. It is a limiting factor to coho salmon throughout the watershed, but certain resource units have the reasonable potential of being cooled to within the coho salmon temperature tolerance. The project is to continuously monitor water temperature in spring and summer (May-September) annually in reaches that are limiting to steelhead and have the potential of cooling to satisfy coho requirements in order to assess the success of revegetation efforts to increase shading and reduce water temperature. Locations of temperature monitoring include the lagoon and the 11 stations listed in Table 1 of the Fisheries Appendix. With this water temperature monitoring over a period of at least 10 years, there will be a measure of restoration success and data to assess when coho may be successfully re-introduced to the watershed.

61: RU8: O& E Program — Collect Oral Histories. Priority 2. While some of the long-time streamside residents are still around, conduct interviews and collect their experiences of the creek. While floods will undoubtedly be recalled, try to get descriptions of the past condition of the water, the fish, the vegetation and how they have changed over time. An oral history of the creek could be compiled from questionnaires, interviews, and/or a public forum.

62. **RU8: O&E Program — Information on Invasive Plants. Priority 1.** Provide information to watershed residents describing the rationale and methods for eradicating invasive exotic plants. Produce and distribute brochure regarding removal of invasive species in understory; or reprint and distribute booklet "A Plague of Plants".

63. **RU8: O&E Program — Riparian Function and Bank Stabilization. Priority 1.** Outreach and education to landowners on bank stabilization and riparian function values. Activities may include workshops, tours, newsletters, media outreach, and direct technical assistance, dissemination of the County of Santa Cruz Stream Care Guide and coordination of resources with interested landowners.

64. **RU8: O&E Program — Mailer on Riparian Values and Property Owner Responsibilities. Priority 1.** Send mailer to landowners. Removal of riparian vegetation on private properties may be an indication that there is not widespread public awareness of the importance of riparian vegetation. Send a mailing to every property owner along the creek, describing the values and functions of vegetation along the creek, Best Management Practices, activities that are regulated by County Ordinance and Fish and Game regulations, and possible penalties for illegal actions. Include the County Stream Care Guide.

65. **RU8: Non-Native Vegetation Removal. Priority 2.** Remove English Ivy from canopy of trees and immediate streamside locations. When English Ivy climbs into the tree canopy, its heavy weight pulls trees down. The climbing stems can be removed from a band around the tree trunk and the upper portion of the Ivy will then wither and lose weight, reducing the immediate threat to the tree. It is desirable also to eradicate the portion of the Ivy on the ground because it suppresses recruitment of native tree saplings.

66. **RU8: Flow Gaging. Priority 1.** Install continuous dry season stream gage just above the lagoon near Nob Hill. There is a positive relationship between lagoon water quality and stream inflow. In addition, although gaging in the past indicated that streamflow declined from the USGS gage to Walnut Street Park, the stream may gain flow between Walnut Street Park and the lagoon. During the drought of the early 1990's, the channel went dry at Walnut Street Park but was flowing again at the lagoon.

67. **RU8: Fish Passage-Stream Flow Interaction Information. Priority 3.** Identify minimum stream flows necessary for fish passage at critical riffles in urbanized reaches and inform residents when water conservation is of particular relevance to fish passage. Flow requirements often vary substantially after large flood flows and will require periodic re-evaluation.

68. **RU8: Landowner Outreach to Relinquish Water Rights for Instream Flows. Priority 1.** Identify landowners willing to petition the State Water Resources Control Board to change a water right in accordance with Water Code Sections 1707 et seq., for the purpose of dedicating streamflow to instream use. Should any landowner prefer to condition modification of a water right on receipt of a monetary consideration (e.g., a conservation easement), then estimate cost: benefit by using results of Instream Flow Incremental Methodology Study to quantify any habitat improvement to directly-affected stream reaches.

69. **RU8: O&E Program – Brochure on Riparian Water Use. Priority 1.** Develop an informational brochure and distribute it at intervals to stream-side landowners regarding minimizing riparian water use and proper reporting of water use under the California Water Code Section 5100 et seq. This section requires (with exceptions) the annual submission of a statement of diversion and use. The statements are for informational purposes only and are

used to determine the names and addresses of persons who are to receive notices with regard to proceedings before the State Water Resources Control Board. In that any proceedings before the Board concerning the Soquel Creek watershed are likely to affect coho salmon and steelhead, the Board should operate with the best available information.

70. RU8: Fish Monitoring. Priority 3. Encourage continued efforts by community members and scientists to conduct annual fishery trending monitoring.

71. RU8: Road Spoil Storage and Disposal. Priority 1. Support the County of Santa Cruz Public Works Department to identify and secure locations for long-term sediment spoil sites should be identified and developed. A significant amount of sediment is removed from inside ditches and road surfaces during the winter months due to general erosion and removal of landslides. Much of this sediment is deposited in road turnouts or on the outside edge of the road surface, only to be eroded further in subsequent storm events. Establishing a site where removed sediment could be effectively disposed of would remove a significant source of sediment to adjacent stream channels.

72. RU8: County Road Database and Emergency Road Repair Fund. Priority 2. Support the County Department of Public Works and Planning to develop a database documenting the existing public road system in the County should be developed within a GIS framework. Grant funding should be pursued for existing road and culvert problems identified in the database. Repairs should be prioritized which will provide the greatest benefits for fish passage and sediment reduction. An emergency road repair fund should also be developed to supplement money available from FEMA for road repairs.

73. RU8: Upgrade Culverts to Prevent Erosion from County Roads. Priority 1. Address high priority problems identified in the Pacific Watershed Associates assessment of problematic culverts and other potential sediment sources on County maintained roads.

74. RU8: O&E - Large Wood, Riparian Vegetation and Flood Management. Priority 2. Support an outreach program to educate agencies and private landowners about the benefits of woody debris and provide a balance, realistic assessment of flood hazard presented by large wood and riparian vegetation. An education program needs to be established that describes the habitat needs of fish and how woody debris plays an important role in their life-cycle. In addition, misconceptions about the danger of large woody debris in the channel should be dispelled. The outreach program could include mailers to streamside residents, public workshops, tours, and other volunteer efforts on local creeks to get residents involved in protecting aquatic and stream resources.

REFERENCES

D.W. Alley and Associates. March 2003. "Soquel Creek Salmonid Assessment and Enhancement Plan, 2003" *in* Santa Cruz County Resource Conservation District. 2003. Soquel Creek Watershed Assessment and Enhancement Project Plan.

Balance Hydrologics, Inc. March 2003. "Soquel Creek Watershed Assessment: Geomorphology and Baseflow Hydrology" *in* Santa Cruz County Resource Conservation District. 2003. Soquel Creek Watershed Assessment and Enhancement Project Plan.

Bryant, G.J. 1994. Status Review of Coho Salmon Populations in Scott and Waddell Creeks, Santa Cruz County California. National Marine Fisheries Service.

California Department of Fish and Game. 1998. Draft Central California Coast Coho Recovery Plan. Monterey, Ca.

Flosi, G., S. Downie, J, Hopelain, M. Bird, R. Coey, & B. Collins. 1998. California Salmonid Stream Habitat Restoration Manual, 3rd ed. California Department of Fish and Game.

Greening Associates. March 2003. "Soquel Creek Riparian Vegetation Assessment." in Santa Cruz County Conservation District. 2003. Soquel Creek Watershed Assessment and Enhancement Project Plan.

Montgomery, D.R. and Buffington, J.M. 1997. Channel-reach morphology in Mountain Drainage Basins. GSA Bulletin, May, 1997, v. 109, no. 5, pp 596-611.

Pacific Watershed Associates. June 2003. "Summary Report—Erosion Prevention Planning Project for County Roads and Roads in the Soquel Demonstrate State Forest, in the Soquel creek Watershed, Santa Cruz County, California. Prepared for Santa Cruz County Resources Conservation District and California Department of Fish and Game.

Santa Cruz County Planning Department. 1986. Soquel Creek Chronic Sediment Source Inventory.

Smith J.J.1990. The Effects of Sandbar Formation and Inflows on Aquatic Habitat and Fish Utilization in Pescadero, San Gregorio, Waddell, and Pomponio Creek/Estuary Lagoon Systems, 1985-1989.

Snider, W., K.A. F. Urquhart, and D. Marston. 1995. The Relationship between instream flow and coho salmon and steelhead habitat availability in Scott Creek, Santa Cruz County, California. CDFG. ESD. Stream flow and habitat evaluation program.

Nelson, J.1993. Personal Communication. Salmon and Steelhead Biologist, California Department of Fish and Game, Monterey, CA.; 1994)

(SWRCB 1998).

APPENDIX A
ADULT SALMONID PASSAGE IMPEDIMENTS

ID	Location	Description	Degree of Passage Impediment
1	Mainstem Soquel Creek- Reach 1	Wide critical riffle just upstream of Nob Hill	Passable at ~ 50-200 cfs
2	Mainstem Soquel Creek- Reach 1	Wide critical riffle just below Grange	Passable at ~ 50-150 cfs
3	Mainstem Soquel Creek- Reach 3	Wide critical riffle upstream of Bates Creek	Passable at ~ 50-200 cfs
4	Mainstem Soquel Creek- Reach 3	Wide critical riffle at lower end of bend near Whitehead's residence	Passable at ~ 50-150 cfs
5	Mainstem Soquel Creek- Reach 5	Wide critical riffle at bend below high sandstone wall	Passable at ~ 50-150 cfs
6	East Branch- just below Ashbury Gulch. N37º05.535'; W121º53.702' At lower end.	Ashbury Falls- Field of Large Boulders, Narrow Canyon- 4 jumps over a span of 165 feet in length.	Passable at ~ 100-150 cfs, likely to collect wood clusters
7	East Branch- just below Ashbury Gulch	Ashbury Falls-Bedrock Shelf-40 ft wide	Passable at ~ 250-300 cfs
8	East Branch- above Ashbury Gulch. N37º05.460'; W121º53.038'	Boulder Falls	Passable at ~ 150 cfs
9	East Branch- above Ashbury Gulch N37º05.388'; W121º52.600'	Steep boulder field creating step- 4.5 feet jump without pool.	Passable at ~ 200 cfs
10	East Branch- 6,100 ft downstream of State Forest Entrance. N37º05.362'; W121º52.278'	Boulder Falls- 6.5 ft jump.	Passable at ~ 350 cfs
11	East Branch- 5,600 ft downstream of State Forest Entrance. 700 ft downstream of large wood cluster just upstream of Highland slide. N37º05.302'; W121º52.170	Boulder/Wood Falls- 10 ft jump.	Passable at ~ 600+ cfs
12	West Branch- 1,000 ft Above Hester Creek	Culverted Ford- No jump required into 4-ft diameter culvert, but culvert plugs each year; 60 ft wide	Often passable when not obstructed.
13	West Branch- 600 ft Above Olsen Rd. 7,750 ft above Hester Creek Confluence.	Girl Scout Falls I- 7-ft drop; chute 15 ft long	Passable at ~ 400 cfs
14	West Branch- 890 ft Above Olsen Rd. 8,000 ft above Hester Creek Confluence.	Bedrock chute- 5-ft drop; chute 10 ft long	Passable at ~ 200 cfs

ID	Location	Description	Degree of Passage Impediment
15	West Branch- 2,600 ft Above Olsen Rd. 9,750 ft above Hester Creek Confluence. N37º04.376'; W121º57.188'	Wood cluster- 10 ft high; 20 ft wide; 30 ft long (Not grade control)	Passable at ~ 30-50 cfs
16	West Branch- 3,660 ft Above Olsen Rd. 10,800 ft above Hester Creek Confluence.	Girl Scout Falls II- 12-15 ft drop; 12 ft wide at bankfull; chute 25 ft long	Passable at ~ 800-1000+ cfs (2-3 times bankfull)
17	West Branch- 10,000 ft Above Olsen Rd. 17,150 ft above Hester Creek Confluence. N37º05.287'; W121º57.674	Tilly's ford- 5 ft high ford without culvert; 50 ft wide	Passable ~ 200-300 cfs
18	West Branch- 11,000 ft Above Olsen Rd. 18,150 ft above Hester Creek Confluence. N37º05.352'; W121º57.790	Gabion Wall across channel- 1-2 ft high	Passable ~ 50-75 cfs
19	West Branch- 23,250 ft Above Olsen Rd; 30,400 ft Above Hester Creek; 1,465 ft below paved road	Laurel Mill Concrete Dam- 12-ft drop, 45 ft wide	Impassable
20	Bates Creek- 2,600 ft Above Main St. N37º00.000'; W121º56.729	Bedrock chute- 7-ft vertical drop over 2 steps, 30 ft long, 17 ft wide	Passable ~ 100 cfs (Above Bankfull)
21	Bates Creek- 3,100 ft Above Main St	Bedrock/Wood falls- 8-ft drop into narrow canyon	Passable ~ 150-200- cfs
22	Bates Creek- 6,900 ft Above Main St	Concrete Dam- 20-30 ft high	Impassable
23	Grover Gulch- 1,920 ft from Mouth	Wood cluster- 4-ft vertical drop, 0.5 ft deep jump pool (sediment delta)	Passable at 40-50 cfs
24	Grover Gulch- 1,995 ft from Mouth	Bedrock chute with LWD- 5-ft drop, 5-ft wide, no jump pool	Passable at 75-100 cfs
25	Grover Gulch- 2,045 ft from Mouth	Wood cluster- 8-ft high, no jump pool	Passable at 150 cfs
26	Grover Gulch- 2,085 ft from Mouth	Wood cluster-4-5 ft high, Loosely aggregated	Passable at Present- Jam with openings available
27	Grover Gulch- 2,100 ft from Mouth	Two logs spanning creek-2.5 ft drop, no jump pool, 25 ft wide	Passable at 75-100 cfs
28	Grover Gulch- 2,187 ft from Mouth	Wood cluster, Old growth involved	Passable at 40-50 cfs but may worsen soon
29	Grover Gulch- 3,390 ft from Mouth	Wood cluster-3-ft drop, 12-ft diameter redwood rootwad involved, at base of landslide	Passable at 30-40 cfs
30	Grover Gulch- 3,475 ft from Mouth	Wood cluster-8-ft high, no jump pool, at upper end of landslide	Passage flow could not be estimated
31	Moores Gulch- 1,521 ft Above Love Creek confluence	Wood cluster- 3-ft vertical drop, 2-ft deep by 20 ft long jump pool	Passable at 30-40 cfs
32	Moores Gulch- 1,825 ft Above	Bedrock falls- 5-ft vertical drop, 4-ft	Passable at bankfull ~ 60-80 cfs

ID	Location	Description	Degree of Passage Impediment
	Love Creek confluence	deep by15-ft long jump pool	

ID	Location	Description	Degree of Passage Impediment
33	Moores Gulch- 1,825 ft Above Love Creek confluence	Bedrock chute- 2.5-ft drop without jump pool	Passable at bankfull ~ 60-80 cfs
34	Moores Gulch- 2,260 ft Above Love Creek confluence	Bedrock falls- 5-ft drop, 5-ft deep by 10-ft long jump pool	Passable at bankfull ~ 60-80 cfs
35	Moores Gulch- 6,207 ft Above Love Creek confluence	Round culvert- 6-ft diameter, 57 ft long with baffles inside	Passable but may become debris collector
36	Moores Gulch- 9,604 ft Above Love Creek confluence	Round culvert (private) - 5-ft diameter, 42-ft long. No drop at bankfull	Passable but may become debris collector
37	Moores Gulch- 9,784 ft Above Love Creek confluence	Round culvert (private) - 5-ft diameter, 25-ft long. Aggradation below	Passable but may become debris collector
38	Moores Gulch- 10,093 ft Above Love Creek confluence	Round culvert (private) - 5-ft diameter, 20 ft long. No drop at bankfull	Passable but may become debris collector
39	Moores Gulch- 11,571 ft Above Love Creek confluence	Round culvert (private) - 5-ft diameter, 25-ft long. Aggradation below.	Passable but may become debris collector
40	Moores Gulch- 12,264 ft Above Love Creek confluence	Round road culvert - 3-ft diameter, 20-ft long. 3-ft drop1 at bankfull. 3-ft deep by 10 ft long jump pool at bankfull	Passability difficult. Culvert undersized and bankfull would flow over road as well as through culvert
41	Hinckley Creek- 5,763 ft from mouth	Bedrock falls with Wood cluster at head- 10-ft drop over chute 6-ft long, 1.5-ft deep jump pool (5-ft deep at bankfull)	Impassable at bankfull or at much higher flows.
42	Amaya Creek- 2,091 ft from mouth N37º04.759'; W121º55.701'	Wood cluster- 7-ft high, 25-ft wide, approach pool 1.5 ft max. depth. Redwood rootwads as catchers.	Passable at ~300+ cfs (Grade control.)
43	Amaya Creek- 2,181 ft from mouth	Wood cluster- 7 ft high, 30 ft wide, 12 ft long, approach pool 1.8 ft max. depth	Passable at ~30-50 cfs (Not grade control.)
44	Amaya Creek- 2,706 ft from mouth	Wood cluster- 6 ft high, 25 ft wide. Very stable. Old-growth log and 3 rootwads as catchers.	Passable at ~300+ cfs (Grade control.)
45	Amaya Creek- 3,886 ft from mouth	Wood cluster- 8 ft high, 35 ft wide. Unstable, caused by debris flow from much landsliding, to supply more wood.	Passable at ~300+ cfs (Grade control.)
46	Fern Gulch- 382 ft from mouth	Wood cluster- 14-ft drop. Pool 5-ft deep by 10 ft long at bankfull.	Impassable
47	Ashbury Gulch- 352 ft from mouth	Boulder cluster- 5-ft vertical drop, 3-ft deep approach pool	Passable at ~ 50-80 cfs
48	Ashbury Gulch- 432 ft from mouth	Split channel boulder cluster- 5.5-ft drop one side into 0.5 ft deep pool; 6-ft drop other side. From 3-ft deep pool at bankfull.	Passable at ~ 100+ cfs
49	Ashbury Gulch- 480 ft from mouth	Boulder cluster- 6-ft vertical drop into 1.2 ft deep pool.	Passable at ~ 100+ cfs
50	Ashbury Gulch- 546 ft from mouth	Large wood cluster from debris slide.	Passage very problematic
51	Hester Creek- 1,656 ft from mouth.	Wood cluster- 5-ft minimum height without jump pool; 25 ft wide. 7-ft diameter redwood stump as catcher.	Passable at ~ 100+ cfs (Grade control.)
52	Hester Creek- 2,379 ft from	Wood cluster on bedrock shelf- 4-ft	Passable at ~ 200 cfs

ID	Location	Description	Degree of Passage Impediment
	mouth	minimum height without jump pool, 20-ft wide	(Grade control.)

ID	Location	Description	Degree of Passage Impediment
53	Hester Creek- 2,620 ft from mouth.	Wood cluster- 6 ft minimum height without effective jump pool	Passable at ~ 200-250 cfs
54	Hester Creek- 2,916 ft from mouth. N37º03.817'; W121º56.396	Wood cluster- 6 ft minimum height, 1.5 ft deep jump pool. 25 ft wide.	1 ft hole in center. If not usable, passable at 200-300 cfs. (Grade control.)
55	Hester Creek- 3,537 ft from mouth	Wood cluster- 3.5 ft minimum height. 2 old growth redwood stumps and standing dead old growth as catchers.	Passable at ~ 150-200 cfs
56	Hester Creek- 4,036 ft from mouth	Bedrock falls with wood cluster on top- 10-ft bedrock falls with additional 7-10 ft of wood on top in a 12-ft wide gorge	Impassable

APPENDIX B
PROJECT SUMMARY MATRIX

PROJECT SUMMARY MATRIX

Resource Unit	RU Code	Proj. #	Type	Description	Problems addressed	Benefits to be achieved	Lead Org/ Agency	Est. Cost	Permits required	RU Priority (H, M, L)	WW Priority (1-5)
RU1 = Upper East Branch - Headwater downstream to Ashbury Falls											
RU1	UEB	1	CE	Conservation Easement / Land Acquisition	Refuge: all	Increase area available for natural channel adjustment, promote chances of natural riparian vegetation recruitment on floodplain, and protect existing refuge areas.	CDFG; SCC: Land Trust(s): open space organizations with land owners involvement	>/=$5mil	none	**H**	2
RU1	UEB	2	Project	Highland Way slide area - perched culvert	Rearing habitat; sediment	Reduce chronic sediment input from toe of landslide and reduce gullying on landslide debris littered slope.	County of Santa Cruz Public Works	15,000-30,000	County	**H**	1
RU1	UEB	3	Project	Inmprove Fish passage at Ashbury Falls	Adult steelhead passage	Increased spawning and rearing habitat.	CDFG; SCC	$20K	1601	**H**	1
RU1	UEB	4	Project	Improve Fish Passage through Boulder Clusters	Adult steelhead passage	Increased spawning and rearing habitat.	CDFG	$100K	1601	**H**	1
RU2 = Mid East Branch - Ashbury Falls downstream to SCW District Weir											
RU2	MEB	5	CE	Conservation Easement / Land Acquisition	Sediment/habitat destruction	Decrease chronic sedimentation due to gullying, road induced slope failures and road cut failures.	CDFG; SCC: Land Trust(s): open space organizations with owners involvement	Million dollars and up	-	**H**	2
RU2	MEB	6	Project	Plant Conifers for Large Woody Material Recruitment	LWM	Cooling summer water temperatures.	SCCRCD; CDF; SDSF.	~$15K	none	**H**	2
RU2	MEB	7	Project	Assess Landslide Stabilization and Sediment Source Reduction in Amaya Creek Watershed	Sediment source	Reduce chronic sedimentation due to toe unraveling by stream processes.	CDF, County, CDFG,	$30K	none	**H**	2
RU3 = Lower East Branch - SCWDistrict Weir downstream to E/W Confluence											
RU3	LEB	8	CE	Conservation Easement / Land Acquisition for Floodplain and Riparian Corridor Protection	Habitat / water temps	Stabilize outside meander bends and promote reestablishment of riparian corridor. Cooling of summer water temperature to satisfy steelhead and coho.	CDFG; SCC: Land Trust(s): open space organizations with owner's involvement	$200K--2Mil/site		**H**	2

CE = Conservation Easement
LWM = Large Woody Material
OE = Outreach/Education

Priorities were assigned by project team based on expected habitat enhancement benefits and ease of implementation.
1 is highest Watershed Wide (WW) priority

PROJECT SUMMARY MATRIX											
Resource Unit	*RU Code*	*Proj. #*	*Type*	*Description*	*Problems addressed*	*Benefits to be achieved*	*Lead Org/ Agency*	*Est. Cost*	*Permits required*	*RU Priority (H, M, L)*	*WW Priority (1-5)*
RU3	LEB	9	Project, O&E Program	Upgrade Flow Gage and Make Information Available on Internet	Reduced summer rearing habitat and data gaps. Fill data gaps; public stewardship development.	Evaluation of enhancement efforts upstream; increase data availability and 'cultivate' landowner stewardship.	SCWD, County	$3-4,000 per gage first year and $1,500 per year thereafter	Santa Cruz County Riparian Permit, 1601	**H**	1
RU3	LEB	10	Project	Re-configure and Revegetate Existing Rip-rap	Habitat, water temp, sedimentation	Reduce opposite bank erosion, keep water temperature cool.	SCCRCD, CDFG,with owner's involvement	expensive	CDFG	**H**	1
RU3	LEB	11	Project	Revegetation at Locations with Limited Shading	Water temp, habitat	Increased shade/Reduced water temperatures.	SCCRCD, with owner's involvement	$50,000-60,000	none	**H**	1
RU3	LEB	12	Project	Assessment of Riparian Vegetation Dieoff	Data gap, Identify. cause for dieoff	Information that may apply elsewhere along the creek.	Potential UCSC Project	$6,000	none	L	5
RU3	LEB	13	Project	Tree Planting Above Bankfull at Transect 58	Water temp	Increased shade/Reduced water temperatures.	SCCRCD, with owner's involvement	$3,000-4,000	none	M	4
RU3	LEB	14	CE	Conservation Easement / Land Acquisition	Habitat quality/protection; Water temp, LWM, BF, vegetation	Decrease chronic sedimentation due to gullying, road induced slope failures and road cut failures.	CDFG; SCC: Land Trust(s): open space organizations with owners involvement	Million dollars and up	-	**H**	2
RU3	LEB	15	O&E Program	Retention of Large Conifers and Wood Clusters in Floodplains	Loss of large conifers in riparian zone, loss of LWM recruitment and stream shading	Increased stream bank stability, cooling of water temperature, increased recruitment of LWM, enhancement of rearing and spawning habitat.	RCD/NRCS, County, Landowners			**H**	2
RU3	LEB	16	O&E Program	Feasibility of Alternatives for Hinkley Creek Wet Crossings	Sediment/habitat destruction	Reduced stream sedimentation, improved spawning and rearing habitat.	SCCRCD, County, SDSF, State Parks,Landowners			L	5
RU3	LEB	17	Project	Erosion Assessment and Mitigation for Hinckley Creek Road	Sediment	Reduced stream sedimentation.	SCCRCD, County, Landowners, Grants			**H**	2
RU4 = West Branch - Headwater downstream A10to E/W Confluence											
RU4	WB	18	CE	Conservation Easement / Land Acquisition	Habitat, Sedimentation	Decrease chronic sedimentation due to gullying, road induced slope failures and road cut failures.	CDFG; SCC: Land Trust(s): open space organizations with owners involvement	Million dollars and up		M	3

CE = Conservation Easement
LWM = Large Woody Material
OE = Outreach/Education

Priorities were assigned by project team based on expected habitat enhancement benefits and ease of implementation.
1 is highest Watershed Wide (WW) priority

PROJECT SUMMARY MATRIX

Resource Unit	RU Code	Proj. #	Type	Description	Problems addressed	Benefits to be achieved	Lead Org/ Agency	Est. Cost	Permits required	RU Priority (H, M, L)	WW Priority (1-5)
RU4	WB	19	Info	Erosion Assessment and Mitigation for Roads	Data gap/ sediment /habitat destruction	Reduced stream sedimentation.	SCCRCD, County, Landowners, Grants			**H**	2
RU4	WB	20	Project	Reestablish discharge gaging station on West Branch, provide internet access to data	Reduced summer rearing habitat and data gaps. Fill data gaps; public stewardship development.	Evaluation of enhancement efforts upstream; increase data availability and 'cultivate' landowner stewardship.	SCWD, County	$3-4,000 per gage first year and $1,500 per year thereafter	Santa Cruz County Riparian Permit, 1601	**H**	2
RU4	WB	21	O&E Program	Encourage Reduction of Stream Diversions	Diminished baseflow, habitat	Increase baseflow during critical periods	County, SCCRCD, CDFG, SWRCB			**H**	1
RU4	WB	22	Info	Assess feasibility of Landslide Stabilization and Erosion Control	Sediment/habitat destruction	Reduced stream sedimentation, improved spawning and rearing habitat.				L	5
RU4	WB	23	Project	Modify Culvert and Old Dams for Fish Passage Improvement	Adult steelhead passage.	Increased spawning and rearing habitat.	CDFG		CDFG 1601, Army Corps 404	M	3
RU4	WB	24	Project	Replace Concrete Ford Upstream of Hester Creek for Fish Passage Improvement	Adult Steelhead passage.	Increased spawning and rearing habitat.	CDFG		CDFG 1601, Army Corps 404	**H**	1
RU4	WB	25	Project	Fish passage Improvement at Tilly's Ford	Adult steelhead passage	Increased spawning and rearing habitat.	CDFG, SCCRCD		CDFG 1601, Army Corps 404	**H**	1
RU4	WB	26	Project	Fish passage Improvement at Bedrock Chutes and Wood Clusters above Olsen Road	Adult steelhead passage	Increased spawning and rearing habitat.	CDFG		CDFG 1601, Army Corps 404	**H**	1

CE = Conservation Easement
LWM = Large Woody Material
OE = Outreach/Education

Priorities were assigned by project team based on expected habitat enhancement benefits and ease of implementation.
1 is highest Watershed Wide (WW) priority

PROJECT SUMMARY MATRIX											
Resource Unit	***RU Code***	***Proj. #***	***Type***	***Description***	***Problems addressed***	***Benefits to be achieved***	***Lead Org/ Agency***	***Est. Cost***	***Permits required***	***RU Priority (H, M, L)***	***WW Priority (1-5)***
RU4	WB	27	Project	Modify Redwood Lodge Road culvert for Passage of Large Woody Material	LWM; Habitat	Increased LVWM downstream, improved habitat	County		CDFG, County	M	3
RU4	WB	28	Project	Landslide Stabilization Feasibility Project, Hester Creek and West Branch	Sediment	Potentially reduce chronic sedimentation from landslide toes (cause fluvial processes).	CRMP	$10,000-15,000		M	4
RU4	WB	29	O&E Program	Move Large Woody Material from Hester Creek into West Branch	LWM/Habitat	Increase LWM in West Branch, Reduce accumulations above culvert	County, CDFG			**H**	1
RU4	WB	30	O&E Program	Community "Creek Clean-up"	Habitat	Enhance water quality, aesthetics.	SCCRCD	$12,000	CDFG, County	**H**	1
RU4	WB	31	Project	Culvert replacement/LWM Passage, Soquel-San Jose Road at Hester Creek	LWM/Habitat	Enhanced spawning and rearing habitat.	County, CDFG			**H**	2
RU5 = Upper Main Stem - E/W Confluence downstream to Moores Gulch											
RU5	UMS	32	CE	Conservation Easement / Land Acquisition	Habitat quality/protection	Water cooling to satisfy coho salmon, provide LWM recruitment, prevent stream sedimentation.	CDFG; SCC: Land Trust(s): open space organizations with owners involvement			**H**	2
RU5	UMS	33	O&E Program	Landowner outreach --Maintenance and Enhancement of Groundwater Recharge	Water Quantity/ Habitat quality/protection	Protect instream flow for salmonid rearing.	SCCRCD, County, SCWD			**H**	1
RU5	UMS	34	O&E Program	Alternatives to Purling Brook Wet-Crossing	sediment/localized habitat destruction	Enhanced spawning and rearing habitat.	Landowners			L	5
RU5	UMS	35	Project	Revegetation of Streamside Areas	Canopy, water temperature, LWM	Water cooling to satisfy coho salmon, provide LWM recruitment.	Landowners			**H**	2
RU5	UMS	36	Project	Revegetation of Bluffs	Canopy, water temperature, LWM	Water cooling to satisfy coho salmon, provide LWM recruitment.	Landowners			M	3
RU5	UMS	37	Project	Revegetation of Bank Stabilization Projects	Habitat quality/protection	Water cooling to satisfy coho salmon, provide LWM recruitment, prevent stream sedimentation.	SCCRCD, Landowners			**H**	2
RU5	UMS	38	Project	Evaluate and Improve Fish Passage at Crossings of Moores Gulch	Passage, LWM		CDFG, Landowners, County			L	5

CE = Conservation Easement
LWM = Large Woody Material
OE = Outreach/Education

Priorities were assigned by project team based on expected habitat enhancement benefits and ease of implementation.
1 is highest Watershed Wide (WW) priority

PROJECT SUMMARY MATRIX											
Resource Unit	***RU Code***	***Proj. #***	***Type***	***Description***	***Problems addressed***	***Benefits to be achieved***	***Lead Org/ Agency***	***Est. Cost***	***Permits required***	***RU Priority (H, M, L)***	***WW Priority (1-5)***
RU5	UMS	39	Project	Improve Fish Passage Movement of Large Woody Material on Moores Gulch at Soquel-San Jose Road	Lack of LWM in main stem	Enhanced spawning and rearing habitat, provide LWM recruitment.	County, CDFG	$+++Mills		M	3
RU6 = Lower Main Stem - Moores Gulch downstream to Nob Hill Area											
RU6	LMS	40	CE	Conservation Easements for Streambank and Floodplain	Habitat quality Floodplain Function	Enhanced spawning and rearing habitat, provide LWM recruitment, prevent stream sedimentation.	CDFG, County, Land Trust			**H**	2
RU6	LMS	41	CE	Water Rights Acquisition through Conservation Easements	Water Quantity; Habitat quality, passage	Maximize summer baseflow to this reach within bounds of historic baseflow variability.	CDFG, County, Land Trust	expensive	none	**H**	2
RU6	LMS	42	Project	Revegetation of Meander Bend	Shade canopy/water temp/ habitat/LWM/ Input of sediment	Increased shade/ Reduced water temperatures; Increase stability of meander bends; Reduce stream sedimentation, improve spawning and rearing conditions; Provide LWM recruitment,	SCCRCD; CRMP; CCC; CDFG	$15,000-20,000 / $100,000-150,000 / 500,000?	none	**H**	1
RU6	LMS	43	Project	Revegetation to Restore Riparian Forest and Reduce Solar Radiation	Shade canopy/water temp/ habitat/LWM/ Input of sediment	Increased shade/Reduced water temperatures; Increase stability of meander bends; Reduce stream sedimentation, improve spawning and rearing conditions, provide LWM recruitment,	SCCRCD; CRMP; CCC; CDFG			**H**	2
RU6	LMS	44	O&E Program	Establish Stakeholder Group to Pursue Increased Baseflow	Recharge/Water Quantity/Water Quality	Reduce Stream Diversions, GW pumping, Increase Baseflow	SWRCB, SCWD, Capitola, County			**H**	1
RU6	LMS	45	Project	Bank Stabilization and Revegetation at Nob Hill	sediment/habitat destruction	Cool water temperature of inflow to the lagoon to satisfy steelhead rearing, reduce sedimentation of the lagoon, decrease input of fines to lagoon, protect few number of trees which occupy the adjacent terrace.	City of Capitola	$35-40,000	CDFG 1601 and Army Corps 404	**H**	2

CE = Conservation Easement
LWM = Large Woody Material
OE = Outreach/Education

Priorities were assigned by project team based on expected habitat enhancement benefits and ease of implementation.
1 is highest Watershed Wide (WW) priority

PROJECT SUMMARY MATRIX											
Resource Unit	*RU Code*	*Proj. #*	*Type*	*Description*	*Problems addressed*	*Benefits to be achieved*	*Lead Org/ Agency*	*Est. Cost*	*Permits required*	*RU Priority (H, M, L)*	*WW Priority (1-5)*
RU6	LMS	46	Project	Shield Creek from Lights under Highway.	Adult steelhead stacking up below Highway 1 Bridge	Improved adult passage and reduced vulnerability to angling pressure.	Caltrans, CDFG, County, Capitola	low $$		**H**	1
RU6	LMS	47	Project	Localized Non-Native Vegetation Removal (Arundo)	Non-native invasive plants	Revitalize native riparian corridor and its diversity, protect native riparian corridor	SCCRCD, County, Community Groups	$20,000	CDFG?	**H**	1
RU6	LMS	48	Project	Extensive Non-native Vegetation Removal: Native Revegetation (Ivy, Broom, Pampas Grass) downstream of Bates Creek	Non-native invasive plants	Revitalize native riparian corridor and its diversity, protect native riparian corridor, cool water temperature of inflow to lagoon to satisfy steelhead rearing.	SCCRCD, County, Community Groups	$20,000	CDFG?	**H**	2
RU6	LMS	49	Project	Feasibility of Percolation Basin Recharge and Detention	Recharge/Water Quantity/Water Quality	Potential Increase local ground water recharge, moderate storm flood peaks (minimal).	County, coordination with Caltrans, Capitola	expensive		M	3
RU6	LMS	50	Project	Stormwater Filtration	Non-point-source pollution entering Soquel Creek through existing storm drain system	Reduce non-point-source pollution and toxicity to aquatic species.	County, Capitola			**H**	2
RU6	LMS	51	Project	Feasibility of Infiltration Galleries	Recharge/Water Quantity/Water Quality	Potential increase in ground water recharge, decrease storm peak flows.	County, Capitola	very expensive-millions		M	3
RU6	LMS	52	Project	Bates Creek Dam Feasibility Study	Barrier or Impediment; Sediment/habitat quality	Increase limited spawning and rearing habitat upstream.Reduce stream sedimentation, improve spawning and rearing conditions in Bates Creek and lower main stem of Soquel Creek.				**H**	2
RU6	LMS	53	Project	Landslide Stabilization Feasibility Project, Bates Creek	Sediment	Reduce sediment				**H**	5
RU6	LMS	54	Project	Replace culvert Crossing of Main Street over Bates Creek	Passage, delivery of LWM	Increase fish passage, movement of LWM				**H**	2

CE = Conservation Easement
LWM = Large Woody Material
OE = Outreach/Education

Priorities were assigned by project team based on expected habitat enhancement benefits and ease of implementation.
1 is highest Watershed Wide (WW) priority

PROJECT SUMMARY MATRIX

Resource Unit	RU Code	Proj. #	Type	Description	Problems addressed	Benefits to be achieved	Lead Org/ Agency	Est. Cost	Permits required	RU Priority (H, M, L)	WW Priority (1-5)
RU6	LMS	55	Project	Non-native Vegetation Removal, Lower Bates Creek	Habitat/canopy quality					M	3
RU6	LMS	56	Project	Fish Passage Improvement, Lower Bates Cr. Bedrock Chute and Falls	Barrier or Impediment					**H**	1
RU6	LMS	57	O&E Program	Advocacy for Use of BMPs for Stables, Nurseries, Residents		Improved protection of riparian corridors, streamflow and water quality	SCCRCD, Community Groups			**H**	1
RU7 = Soquel Creek Lagoon - Nob Hill Area downstream to Mouth of Soquel Creek											
See Capitola Lagoon Enhancement Plan											
RU8 = Watershed Wide - Throughout the entire watershed											
RU8	WW	58	Project	Erosion Assessment and Sediment Reduction for Non-county Roads	Sediment/habitat destruction	Decrease chronic sedimentation due to gullying and road cut failures.	Open: NRCS/SCCRCD	$1000/mile (~600K$)	none	**H**	2
RU8	WW	59	Project	Instream Flow Modeling to estimate streamflow needed for habitat.	Water Quantity; Habitat quality, passage	Assess habitat needs and encourage water conservation.	CDFG, NMFS			**H**	1
RU8	WW	60	Monitor-ing	Water Temperature Monitoring	High water tempera-ture and data gaps	Evaluation of enhancement efforts upstream.	CDFG, NMFS, County			**H**	1
RU8	WW	61	O&E Program	Collect oral histories	Shortage of historical info	Help to define historical parameters of stream behavior and normal range of fluctuations.	SCCRCD	$10,000	n/a	**H**	2
RU8	WW	62	O&E Program	Brochure regarding invasive exotic plants	Invasion by exotic pest plants	Protect existing riparian vegetation from further damage, improve fish habitat.	SCCRCD	$15-20,000	n/a	**H**	1
RU8	WW	63	O&E Program	Brochure regarding bank stabilization	Habitat improvement on stream banks		SCCRCD, County, CDFG			**H**	1
RU8	WW	64	O&E Program	Mailer on Riparian Values and Property Owner Responsibilities	Uninformed stewardship by streamside residents	Improved stewardship by streamside residents.	SCCRCD, CDFG	$18-22,000	n/a	**H**	1
RU8	WW	65	Project	Non-native Vegetation Removal: Remove Ivy from canopy	Invasion by exotic pest plants	Protect existing riparian trees from damage.	SCCRCD	$8,000	n/a	**H**	2

CE = Conservation Easement
LWM = Large Woody Material
OE = Outreach/Education

Priorities were assigned by project team based on expected habitat enhancement benefits and ease of implementation.
1 is highest Watershed Wide (WW) priority

PROJECT SUMMARY MATRIX											
Resource Unit	*RU Code*	*Proj. #*	*Type*	*Description*	*Problems addressed*	*Benefits to be achieved*	*Lead Org/ Agency*	*Est. Cost*	*Permits required*	*RU Priority (H, M, L)*	*WW Priority (1-5)*
RU8	WW	66	Moni-toring Plan	Stream flow Monitoring	Reduced summer rearing habitat in the lagoon and data gaps	Evaluation of enhancement efforts upstream, protection of inflow to the lagoon for steelhead rearing.	CRMP; CWC; SCCRCD	$5000/yr		**H**	1
RU8	WW	67	Info	Fish Passge - Stream Flow Interaction Information	Water Quantity; Habitat quality, passage	Assess habitat needs and encourage water conservation.				M	3
RU8	WW	68	O&E Program	Landowner Outreach to Relinquish Water Rights for Instream Flows	Water Quantity; Habitat quality, passage	Reduce water use and protect instream flows				M	3
RU8B	LWW	69	O&E Program	Brochure on Riparian Water Use	Water Quantity; Habitat quality, passage	Encourage responsible use and reporting of surface water use.				**H**	1
RU8B	LWW	70	O&E Program	Encourage continued community fish monitoring efforts		Assess lagoon fishery productivity	Capitola, community groups		Collec-tion	M	3
RU8	WW	71	Project	Road Spoil Storage and Disposal	Sediment	Prevent erosion and slumping of sidecast material	County			**H**	1
RU8	WW	72	Info Project	County Road Database and Emergency Road Repair Fund	Sediment		County			**H**	2
RU8	WW	73	Project	Upgrade Culverts to Prevent Erosion from County Roads	Sediment		County			**H**	1
RU8	WW	74	O&E Program	O&E - Large Wood, Riparian Vegetation and Flood Management	Riparian vegetation, LWM, Habitat		County, SCCRCD, CDFG			**H**	2

CE = Conservation Easement
LWM = Large Woody Material
OE = Outreach/Education

Priorities were assigned by project team based on expected habitat enhancement benefits and ease of implementation. 1 is highest Watershed Wide (WW) priority